

**. . . . Short-Term Petroleum
Outlook An Examination
of Issues and Projections**

An Emergency Preparedness Report of the
National Petroleum Council.. January 1991

NATIONAL PETROLEUM COUNCIL

1625 K Street, N.W., Washington, D.C. 20006 (202) 393-6100

January 23, 1991

The Honorable
James D. Watkins
Secretary of Energy
Washington, D.C. 20585

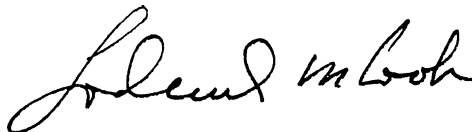
Dear Mr. Secretary:

On behalf of the members of the National Petroleum Council, I am pleased to transmit to you herewith two emergency preparedness reports, Industry Assistance to Government -- Methods for Providing Petroleum Industry Expertise During Emergencies, and Short-Term Petroleum Outlook -- An Examination of Issues and Projections. These reports were prepared in response to your requests and were unanimously approved by the membership at their meeting today. The first report recommends three types or levels of industry response to requests from government for industry information, advice, and assistance. You have already utilized Level 1, company emergency contacts, and Level 2, executive advisory groups. The third level, a petroleum-related National Defense Executive Reserve, as you know, will require legislative action to remove impediments to service by industry personnel.

The second report discusses significant issues relating to the short-term worldwide supply and demand for crude oil and refined petroleum products. Emphasis is placed on ways in which the complex but flexible petroleum distribution system can be expected to deal with the effects of various types of problems. At present, the issue of most immediate interest and concern is the potential effect of a significant further disruption of petroleum exports from the Middle East. The Council's report recommends several actions to ensure that the impact of such a disruption on military needs and the U.S. economy, if it were to occur, would be minimized. The Council also cautions against certain types of government response that could reduce the ability of the petroleum supply system to respond effectively. The National Petroleum Council is pleased that the President and you have recently taken a number of the steps recommended by the Council.

The Council sincerely hopes that these two emergency preparedness reports will be of continuing assistance to you and the President in dealing with the current situation and in preparing for future contingencies.

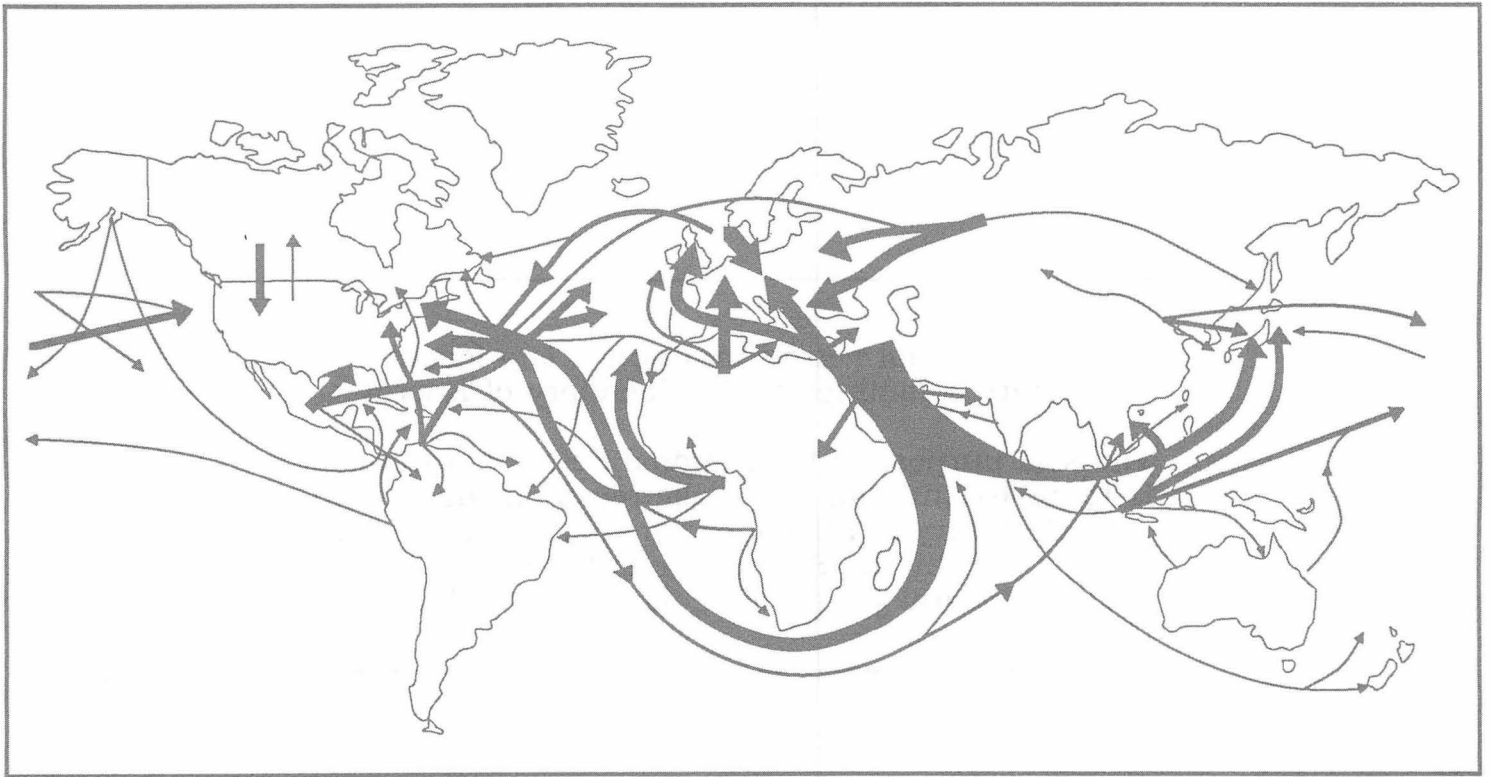
Respectfully submitted,



Lodwick M. Cook
Chairman

Enclosures

An Advisory Committee to the Secretary of Energy



. . . . Short-Term Petroleum Outlook An Examination of Issues and Projections

An Emergency Preparedness Report of the
National Petroleum Council.. January 1991

..... Prepared by the National Petroleum Council's Committee on Emergency
Preparedness . . . Robert McClements, Jr., Chairman . . . with the Assistance of
the Short-Term Outlook Subcommittee . . . Riad N. Yammine, Chairman

NATIONAL PETROLEUM COUNCIL

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U.S. DEPARTMENT OF ENERGY

James D. Watkins, *Secretary*

The National Petroleum Council is a federal
advisory committee to the Secretary of Energy.

The sole purpose of the National Petroleum Council
is to advise, inform, and make recommendations to
the Secretary of Energy on any matter requested
by the Secretary relating to
oil and natural gas or to the oil and gas industries.

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TABLE OF CONTENTS

INTRODUCTION	1
EXECUTIVE SUMMARY	3
PART I: Issues Affecting the Short-Term Petroleum Supply/Demand Outlook	11
PART II: Review of the EIA Short-Term Energy Outlook Process and Models	47
APPENDICES	
Appendix A: Request Letter and Description of the National Petroleum Council	A-1
Appendix B: Study Group Rosters	B-1
Appendix C: EIA <i>Petroleum Prices and Profits in the 90 Days Following the Invasion of Kuwait</i> - Overview	C-1
Appendix D: NPC <i>System Dynamics</i> - Executive Summary, and Validation by Recent Events	D-1
INDEX	IN-1

INTRODUCTION

On August 2, 1990, Iraq invaded Kuwait, capturing the entire country. The Iraqi invasion cut off 1.3 million barrels per day of Kuwaiti crude oil and refined product exports to the world. The U.N. embargo slashed world oil supplies by another 3 million barrels per day by cutting off Iraqi exports. The result was a significant increase in the worldwide price of crude oil and petroleum products. This price rise, coupled with political considerations, resulted in other oil producing countries gradually increasing their oil production since August 2 to a level that has replaced lost Kuwaiti and Iraqi supplies. The increased price of oil also has brought about substantial reductions in oil demand. In addition, economic growth has been trending downward for two years, and this has helped reduce the growth rate in oil demand. In short, the world petroleum system was subjected to a major shock that caused a rebalancing of supply and demand. Currently the system has little spare crude oil production capacity.

The U.S. Department of Energy (DOE) closely monitored and analyzed world and U.S. petroleum markets following the Iraqi invasion of Kuwait and, by letter dated October 19, 1990, Secretary of Energy James D. Watkins requested the National Petroleum Council's (NPC) "assessment of the issues shaping the short-term supply/demand outlook." The Secretary asked for "at the earliest possible date" quarterly estimates through mid-1991 and "an analysis of the factors that can affect those estimates." Several specific examples of the factors to consider were given: "crude availability and quality, refinery utilization and impact of turnaround schedules, regulatory impediments to reactivating mothballed refineries, product exports and imports, inventory draw/build and use of the SPR." Finally, the Secretary noted the potential for competitive and legal concerns and offered to make the assumptions and results of the Energy Information Administration's (EIA) *Short-Term Energy Outlook* available to the Council. (See Appendix A for the complete text of the Secretary's request letter and a description of the National Petroleum Council.)

At the time this request was made, the NPC Committee on Emergency Preparedness was preparing a response to an earlier request from the Secretary that resulted in a companion report of the NPC, *Industry Assistance to Government—Methods for Providing Petroleum Industry Expertise During Emergencies*. The NPC Committee on Emergency Preparedness was also charged with preparing a response to the Secretary's October 19 request. The Committee was chaired by Robert McClements, Jr., Chairman of the Board and Chief Executive Officer, Sun Company, Inc. The Honorable Linda G. Stuntz, Deputy Under Secretary, Policy, Planning and Analysis, U.S. Department of Energy, was designated by Secretary Watkins to co-chair the Committee for this portion of its work. To assist the Committee, a Subcommittee on Short-Term Outlook was formed under the chairmanship of Riad N. Yammine, President, Emro Marketing Company. Jimmie L. Petersen, Director, Office of Oil & Gas, Energy Information Administration, served as Government Cochairman. The membership of the Subcommittee on Short-Term Outlook was drawn

primarily from the Coordinating Subcommittee of the NPC Committee on Petroleum Storage & Transportation, whose report, as the Secretary noted in his letter, had been "particularly helpful to our understanding of the workings of the petroleum distribution system." Additional members were also drawn from the ongoing Subcommittee on Emergency Preparedness. (Rosters of the study groups are contained in Appendix B.)

At the outset of the study, it was determined that creating new supply/demand projections could not reliably be completed within a 60-90 day time frame. It was further determined that the *Short-Term Energy Outlook* reports of the Energy Information Administration are among the most complete and generally accepted publicly available projections. In recognition of these factors, the NPC elected to conduct a thorough review and validation of the methodology used by the EIA in lieu of developing its own projections.

Accordingly, the EIA's fourth quarter projections are used in this report to represent a reasonable estimate of U.S. petroleum supply and demand in the first two quarters of 1991. It must be recognized, however, that quarterly or even monthly data may not reveal brief or local problems that may arise. These problems can be expected to be dealt with by the supply system, but perhaps not without consumer inconvenience or the potential for isolated cases of product shortages. It is the intent of this report to explain how the worldwide petroleum distribution system operates to ensure adequate supplies. The report also examines government actions that can complement or complicate the workings of the system.

As Secretary Watkins requested, the focus of this analysis is to highlight potential supply problems in the first six months of 1991. An analysis of how the system worked to avert physical shortages following the Iraqi invasion was conducted by the EIA and reported in *Petroleum Prices and Profits in the 90 Days Following the Invasion of Kuwait*. The Overview of the EIA report is reprinted in Appendix C.

Finally, as Secretary Watkins noted in his request letter, the 1989 NPC report *Petroleum Storage & Transportation*, especially its volume on System Dynamics, has been useful in understanding the workings of the petroleum distribution systems. The System Dynamics volume is a detailed analysis of how the U.S. oil and natural gas system works, both in normal times and during periods of "stress"—when unusual occurrences severely hamper normal system operation. As part of that analysis, the NPC constructed several hypothetical stress situations.

Since the publication of the System Dynamics volume, two stress situations similar to two of the hypothetical cases have occurred—the March 1989 tanker accident interrupting deliveries from the Trans-Alaska Pipeline System and the December 1989 severe cold weather. These two situations were examined to test the validity of the 1989 analysis. The Executive Summary of that volume and examinations of the 1989 stresses are presented in Appendix D.

EXECUTIVE SUMMARY

FINDINGS AND CONCLUSIONS

This report examines projections and issues shaping and affecting the short-term petroleum supply/demand outlook. Uncertainty exists in forecasting the future due to complex global interactions. However, the world and U.S. oil markets have historically adjusted to the effects of major problems. The NPC makes the following key findings and conclusions based on its analysis of the current situation and potential future disruptions in global supply:

- The U.S. is part of the world petroleum supply system that is driven by free-market economics and is effective in responding to a wide variety of disruptions. The U.S. cannot insulate itself from the world market.
- In a disruption, prices will increase and short-term product shortages may develop, particularly if hoarding occurs.
- Any government action designed to artificially lower prices can intensify short-term disruptions and potentially reduce longer term effectiveness of the system.
- Barring a significant further crude oil supply disruption, world-wide and domestic refining and logistics capabilities are assessed to be adequate to respond to a range of "normal" contingencies (e.g., severe weather, unscheduled refinery shutdowns) without government intervention.
- The only contingency requiring significant government action would be a large additional reduction in worldwide crude oil availability. If there is an outbreak of hostilities or other events that could disrupt the flow of oil from the Middle East, immediate announcement of the release of Strategic Petroleum Reserve (SPR) oil is vital, ideally in conjunction with release of International Energy Agency (IEA) strategic stocks, but unilaterally if necessary.
- Expedited or blanket Jones Act waivers will likely be required in conjunction with SPR release to allow timely transportation of SPR oil.
- If the additional supply shortfall is expected to be significantly larger than the SPR can satisfy and of an extended duration, government action may be required to reduce demand.
- A uniform statutory and regulatory environment, rather than a patchwork of state regulations and controls, is needed to maintain the flexibility of the petroleum supply system to respond in emergencies.

As a result of a detailed review, the NPC concludes that the process and models used to develop the EIA's *Short-Term Energy Outlook* yield

reasonable and appropriate results. Further, the Council concludes that the EIA's report *Petroleum Prices and Profits in the 90 Days Following the Invasion of Kuwait* is an excellent retrospective commentary on what occurred in world petroleum markets following the August 2 invasion of Kuwait.

The System Dynamics volume of the 1989 NPC report *Petroleum Storage & Transportation* provides a detailed foundation for understanding the capabilities and resiliency of the domestic petroleum supply system. The analysis of two recent real-world stresses to the system validates the basic findings of the 1989 report.

SHORT-TERM PETROLEUM OUTLOOK—ISSUES

The examination of issues shaping and affecting the short-term petroleum supply/demand outlook first addresses the worldwide nature of petroleum markets and the forces that rebalance the system. Next, current system capabilities and the ability of the system to respond to further stresses are assessed. Finally, government actions that could assist in minimizing the impacts of further stresses, particularly the use of the SPR, are addressed.

Worldwide Market (See pages 12 - 23)

The oil market is a global system continually responding to many minor stresses. Market reactions are the result of thousands of independent, competing industry decisions and reflect classic supply/demand forces. Constrained supply (whether an actual, anticipated, or perceived shortage) results in higher prices. Depending on the significance of the supply disruption, the price response can be very large. Actual and anticipated oil prices are a driving force in balancing present and future oil supply and demand. There are systems in place, the futures markets for example, that provide liquidity, price transparency, and a mechanism to manage risk.

The U.S. crude oil and product distribution system is very flexible, allowing quick response to demand spikes or supply disruptions. With the exception of a major crude oil disruption that cannot be offset by an SPR drawdown, experience and this assessment suggest that any potential problems would be localized and quickly alleviated. System inventories provide surge capacity to minimize the impacts of disruptions.

For market forces to work most effectively, government intervention such as allocation, price controls, and jaw-boning is counterproductive. The rebalancing of supply and demand occurs most rapidly and efficiently if prices are permitted to reflect market conditions.

Current System Assessment *(See pages 24 - 29)*

The immediate loss of production from Kuwait and Iraq has now been offset by increases in other producing countries, leaving little spare crude oil production capacity to compensate for future disruptions. With respect to crude oil quality, worldwide supplies have become heavier by a small amount, but crude oil sulfur content has marginally improved. Although refining yields have shifted slightly toward residual fuel oil, the overall impact has been minimal.

The industry refers to three general categories of refineries. The topping/reforming refinery is the simplest, and makes the least amount of light product, such as gasoline, jet fuel, and home heating oil, from a barrel of crude oil (40-60%). In the cracking refinery, additional equipment is available to make more light product (55-70%). In the most sophisticated type of refinery (one with a cracker and coker), almost 90% of the oil is made into light product.

Surplus world refinery capacity exists today. Typically, economics ensure that the more sophisticated refineries are being fully utilized so the spare refining capacity that is available yields a smaller percentage of the more desirable lighter products. For that reason, the relatively sophisticated Kuwaiti refining capacity that was lost has been replaced by other less sophisticated refineries. In refining terminology, the worldwide conversion balance has tightened, but is assessed to be adequate to meet a reasonable range of product requirements.

The U.S. refining system is fully integrated into the larger world refining system. Over the last several years, U.S. product imports have averaged about 2 million barrels per day while U.S. refined product exports averaged over 600 thousand barrels per day. The United States has some spare primary distillation capacity, but during peak demand periods there is essentially no spare cracking or coking capacity. The system has flexibility to handle unexpected refinery shutdowns, but some regional supply imbalances could occur. In the event of significant refinery outages, additional product imports would be required. Conversely, operating situations may, at times, require additional exports to operate the refining system efficiently.

Further System Stress *(See pages 30 - 39)*

At the end of 1990, little spare crude oil production capacity existed in the world. If further major supply disruptions occur, strategic reserves must be utilized to balance the system.

As stated, surplus world refining capacity exists today, but the majority of the surplus is unsophisticated. Refining capacity will not be constrained and, in fact, will be a secondary issue, if world crude oil production capacity is disrupted. It is the NPC's opinion that isolated

refinery disruptions, even in relatively large and sophisticated plants, are unlikely to result in physical shortages. It is, however, important to note that in spite of the overall adequacy of refinery capacity, the loss of several major sophisticated refineries or a sharp increase in apparent demand due to hoarding could cause regional problems. Response to these regional problems can be costly and may take some time to be effective.

An unanticipated U.S. pipeline shutdown could cause some short-term regional imbalances/shortages. The distribution system in the U.S. is flexible and would respond quickly to disruptions, thus any outages would be localized and quickly alleviated. However, the limited availability of Jones Act tankers could slow domestic rebalancing wherever logistics require such tankers.

Certain regional stresses, such as cold weather, may cause isolated shortages. But this is not unusual in times of demand surges. The system responds to the temporary shortage through higher prices, but increased supply quickly follows and prices fall.

Government Response *(See pages 18 - 23 and 40 - 45)*

Government response is essential to minimize disruptions if there is a further significant decrease in worldwide crude oil supplies. Because crude oil production is essentially at capacity as of the end of 1990, a large additional disruption can only be offset by the release of strategic stocks. The NPC recommends that SPR volumes be offered immediately if there is an outbreak of hostilities or other events that could disrupt the flow of oil from the Middle East. This action would be a clear signal to U.S. and world markets of the intent of the U.S. government to make stocks available to maintain continuity of supply. Ideally, this action would be in conjunction with the release of other IEA strategic stocks, but the decision to offer SPR oil for bid should not be contingent on international agreement.

While the specific volume to be released should depend on the assessment of the nature and duration of the disruption, the ability to plan for initial SPR deliveries starting in three to four weeks should provide adequate commercial flexibility to bidders. In the event of a Middle East supply disruption, the early commitment to draw down the SPR would tend to calm petroleum markets. The need for further releases and the appropriate volume of future offerings could be assessed later as the situation becomes clearer.

Coincident with the offering of SPR oil for bid, the government will need to expedite the processing of Jones Act waivers to allow prompt distribution of SPR oil. While the political difficulty with some form of blanket waiver is recognized, the delays and commercial inflexibility of the ship-by-ship waiver process will significantly constrain the ability to distribute SPR oil. If a significant reduction occurs in product imports into the Northeast, similar Jones Act waivers may be required for product tankers.

Depending on the severity and duration of any crude oil supply disruption, additional action by the government may be required to temporarily restrain demand, encourage conservation, and—over the longer term—encourage domestic production. These efforts should be undertaken to the extent possible within the framework of market prices and unrestrained product movements, both import and export. Past experience has demonstrated that unfettered market behavior is the most efficient allocator of limited resources.

Under the current situation, relaxation of product quality regulations is not necessary. However, in the event of a further severe disruption, government action may be helpful to permit maximum refinery yield of the most critical heating and transportation fuels. Potential steps include the delay of summer Reid Vapor Pressure (RVP) reductions, which would increase gasoline production, and the temporary relaxation of distillate sulfur limits. The effect of these actions is relatively minor and, under most circumstances, sufficient capacity exists to meet a reasonable range of expected demands without them.

Government action may also be required to help alleviate hardships caused by price increases that would invariably accompany further disruptions. While the free market provides the most efficient and effective response to any supply disruption or demand surge, the Council fully recognizes that a consequence will be that some elements of our society will face severe hardships. The principal role of the industry in these situations is to maintain continuity of product supply for consumers and the principal role of governments is to minimize hardships. Industry and government have historically cooperated during times of crisis and are expected to do so in the future. In addition, industry and government should commit to consumer educational efforts designed to promote energy conservation.

One type of government response that may be counterproductive is commonly referred to as jaw-boning. This is a long-standing and powerful political tool. American industry has traditionally complied with the requests of national leaders to make supply, manufacturing, logistical, pricing, or other decisions that may not be compatible with its interests or market conditions. The NPC is not questioning the prerogative of elected officials to seek to influence industry actions. However, the consequences of jaw-boning should be recognized—it will likely exacerbate supply problems and delay the rebalancing of supply and demand. Artificially constraining prices tends to discourage conservation, slows the flow of needed supplies, and can lead to run-outs. In the extreme, the longer term effect can be reduced industry investment.

Some might advocate closing the futures market in the U.S. (New York Mercantile Exchange, NYMEX) in the event of an emergency. However, futures markets have become highly integrated with the dynamic global oil markets. These futures markets provide for price discovery and a mechanism to reduce risk. In addition, they have become a widely used price clearinghouse to effect wet-barrel transactions through the

exchange-for-physicals procedure. The NPC believes that closing the NYMEX in an emergency would be disruptive.

Finally, the NPC stresses the importance of a uniform statutory and regulatory environment in lieu of a patchwork of state regulations and controls. For example, there is continuing concern that differing state unlimited oil spill liability provisions may limit system flexibility by discouraging shippers from bringing tankers into U.S. ports. Initiatives by some states to impose price or allocation controls will also limit the ability of the system to respond efficiently in emergency situations.

SHORT-TERM PETROLEUM OUTLOOK—PROJECTIONS

The EIA energy supply/demand projections are among the most complete and generally accepted publicly available projections. Due to time constraints, the NPC elected to validate these projections rather than create a new supply/demand projection for the first and second quarters of 1991.

The review and validation of the EIA's *Short-Term Energy Outlook* process and models began with a thorough examination of the methodology used by the EIA, which consists of econometric and time-series forecasting techniques, market clearing assumptions, and data analysis and judgment by EIA personnel. Next, the EIA process was tested for response to change in basic input parameters. Finally, the various segments of the model were analyzed for appropriateness of structure and strength of relationship.

Given any reasonable set of bases, the EIA method of producing a short-term outlook yields appropriate results. Table 1 provides a summary of the middle crude oil price case from the EIA's *1990 Fourth Quarter Short-Term Energy Outlook*.

The review and validation effort, however, identified a few concerns relating to the models and process employed. The concerns highlighted here are indications of where more analytical effort should be applied but do not alter the conclusion that the EIA process currently provides reasonable results.

- The interactive nature of the *Short-Term Energy Outlook* methodology for the United States results in the outlook process being highly dependent on the availability of experienced government personnel in all contributing areas. The current experience level available is adequate.
- The procedure followed for developing the international projection, while rigorous, does not employ mathematical models and, therefore, is very dependent upon the experience of government personnel and the cooperation of industry. As with the U.S. outlook procedure, the international process currently works well.

TABLE 1
SUMMARY OF EIA'S SHORT-TERM ENERGY OUTLOOK PROJECTIONS
\$30 World Oil Price Case

Assumptions and Projections	Year				Annual Percentage Change		
	1988	1989	1990	1991	1988-1989	1989-1990	1990-1991
Macroeconomic Indicators							
Real Gross National Product (billion 1982 dollars)	4,017	4,118	4,160	4,192	2.5	1.0	0.8
Index of Industrial Production (Mfg.) (index, 1977 = 1.000)	1.058	1.089	1.099	1.099	2.9	.9	.0
Imported Crude Oil Price (nominal dollars per barrel)	14.56	18.08	22.30	30.00	24.2	23.3	34.5
Retail Prices (nominal) ^a							
Motor Gasoline ^b (dollars per gallon)96	1.06	1.22	1.46	10.4	15.1	19.7
No. 2 Heating Oil (dollars per gallon)81	.90	1.06	1.29	11.1	17.8	21.7
Residential Natural Gas (dollars per thousand cubic feet)	5.47	5.64	5.83	6.23	3.1	3.4	6.9
Residential Electricity (cents per kilowatthour)	7.49	7.64	7.89	8.24	2.0	3.3	4.4
Petroleum Supply							
Crude Oil Production ^c (million barrels per day)	8.14	7.61	7.26	7.21	-6.5	-4.6	-7
Net Petroleum Imports, Including SPR (million barrels per day)	6.59	7.20	7.47	6.62	9.3	3.7	-11.4
Energy Demands							
Total Market Economies Petroleum Consumption (million barrels per day)	51.05	52.37	52.92	51.75	2.6	1.1	-2.2
Total U.S. Petroleum Consumption (million barrels per day)	17.28	17.33	16.99	16.26	.3	-2.0	-4.3
Motor Gasoline	7.34	7.33	7.25	7.03	-.1	-1.1	-3.0
Jet Fuel	1.45	1.49	1.52	1.45	2.8	2.0	-4.6
Distillate Fuel Oil	3.12	3.16	3.01	2.90	1.3	-4.7	-3.7
Residual Fuel Oil	1.38	1.37	1.24	1.00	-7	-9.5	-19.4
Other Petroleum ^d	4.00	3.98	3.97	3.88	-.5	-.3	-2.3
Natural Gas Consumption (trillion cubic feet)	18.03	18.78	18.49	19.28	4.2	-1.5	4.3
Coal Consumption (million short tons)	884	889	892	923	.6	.3	3.5
Electricity Sales ^e (billion kilowatthours)	2,578.1	2,633.8	2,705.3	2,775.9	2.2	2.7	2.6
Gross Energy Consumption ^f (quadrillion Btu)	80.20	81.24	80.89	81.15	1.3	-.4	.3
Thousand Btu/1982 Dollar of GNP	19.97	19.73	19.44	19.36	-1.2	-1.5	-.4

^a All prices include taxes, except prices for No. 2 heating oil and residential electricity.

^b Average for all grades and services.

^c Includes lease condensate.

^d Includes crude oil product supplied, natural gas liquids, liquefied refinery gases, other liquids, and all finished petroleum products except motor gasoline, jet fuel, and distillate and residual fuel oils.

^e Total annual electricity sales for historical periods are derived from the sum of monthly sales figures based on submissions by electric utilities of Form EIA-826, "Monthly Electric Utility Sales and Revenue Report with State Distributions." These historical values differ from annual sales totals based on Form EIA-861, reported in several EIA publications, but match alternate annual totals reported in EIA's *Electric Power Monthly*, DOE/EIA-0226.

^f The conversion from physical units to Btu is calculated using a subset of *Monthly Energy Review* (MER) conversion factors. Consequently, the historical data may not precisely match that published in the MER.

SPR: Strategic Petroleum Reserve

Notes: Minor discrepancies with other published EIA historical data are due to independent rounding. Historical values are printed in **boldface**, forecasts in *italics*.

Sources: Historical data: Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(90/07); *International Petroleum Statistics Report*, DOE/EIA-0520(90/09); *International Energy Annual 1988*, DOE/EIA-0219(88); *Petroleum Marketing Monthly*, DOE/EIA-0380(90/07); *Petroleum Supply Monthly*, DOE/EIA-0109(90/07); *Petroleum Supply Annual 1989*, DOE/EIA-0340(89)/1; *Natural Gas Monthly*, DOE/EIA-0130(90/07); *Electric Power Monthly*, DOE/EIA-0226(90/07); and *Quarterly Coal Report*, DOE/EIA-0121(90/2Q); Organization for Economic Cooperation and Development, *Monthly Oil Statistics Database* through June 1990. Macroeconomic projections are based on DRI/McGraw-Hill Forecast CONTROL1090.

Energy Information Administration/ Short-Term Energy Outlook, Fourth Quarter 1990

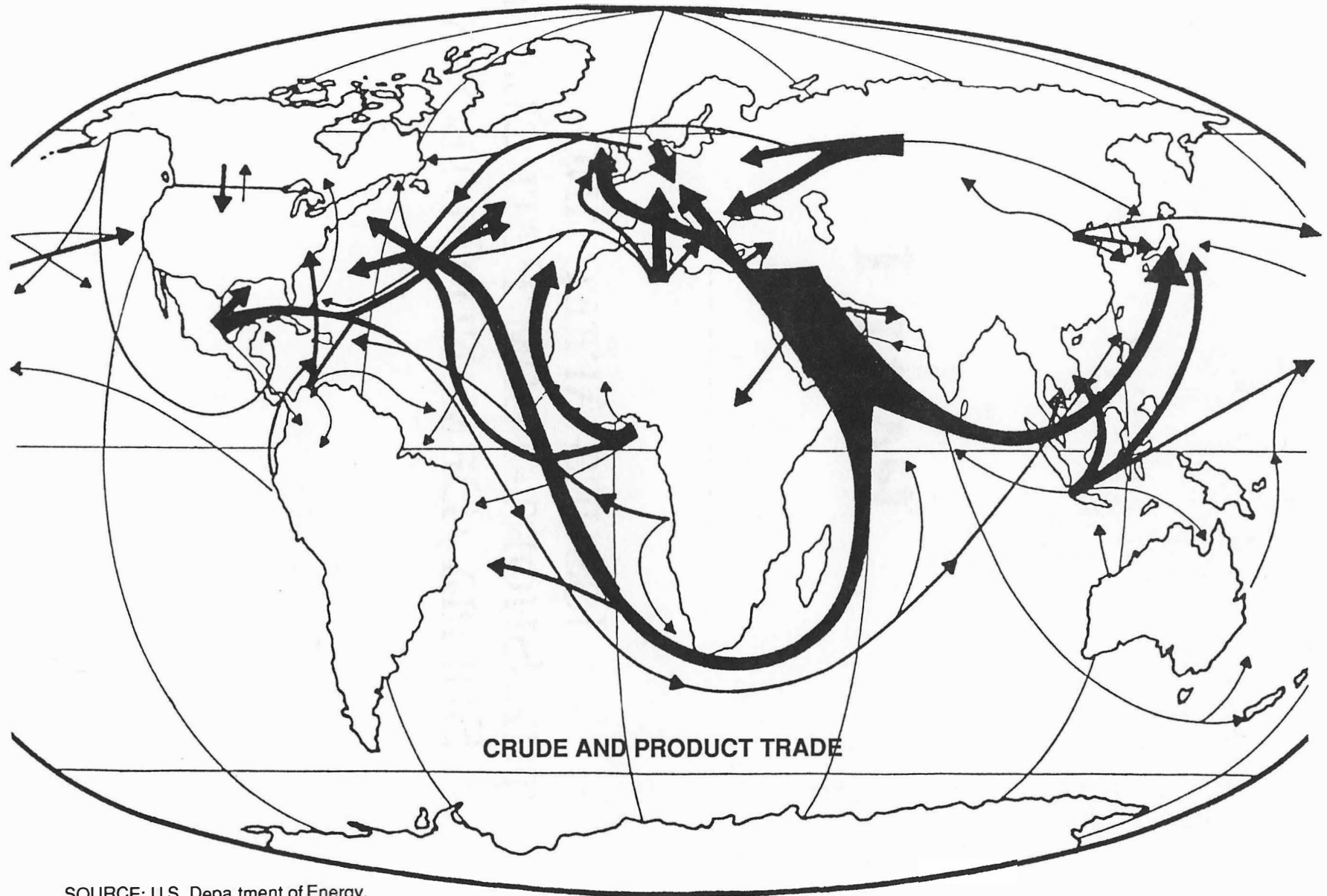
- It is essential to the integrity of the process that the EIA ensure continued expertise in these areas.
- The short-term response of domestic crude oil and condensate production to price appears excessive. This was most evident in the difference between the production estimate for the boundary price cases included in the *1990 Fourth Quarter Short-Term Energy Outlook*.
- Substitution of natural gas for oil does not seem to be adequately addressed. While this is a concern, the impact on oil demand is not a major factor for situations close to today's conditions.
- The dynamics of distillate and residual fuel oil use for power generation are not adequately portrayed. As in the case of natural gas substitution, the effect is not major.
- The EIA short-term modeling process, like all other econometric modeling processes, is not designed to deal with situations outside the bounds of experience. However, in the analysis of severe supply disruptions, the knowledge and expertise of the outlook process participants could provide useful insights and judgments about the situation.

In order to test the EIA process and models, two alternate cases were devised. In one, the crude oil price profile specified for 1991 ranged up to \$10 above the EIA's middle crude oil price case (\$30) for the first half of the year and up to \$10 below it for the second half of the year. The price range of the test case is similar to the actual range of prices experienced over the last year. However, it must be stressed that this alternative price profile is not intended to be a forecast or projection, but only a reasonable deviation from the base case for test purposes. In the other test case, the process responsiveness was tested for lower economic activity. All energy supply/demand values changed in expected directions with reasonable relative magnitudes. The models and methodologies used by the EIA are described in detail in Part II of this report.

PART I

ISSUES AFFECTING THE SHORT-TERM PETROLEUM SUPPLY/DEMAND OUTLOOK

WORLD PETROLEUM MARKETS COMPLEX AND INTERDEPENDENT



SOURCE: U.S. Department of Energy.

WORLD PETROLEUM MARKETS COMPLEX AND INTERDEPENDENT

OVERVIEW—The oil market is a global system, with individual regions linked by the trade flows shown on the map on the facing page.

- On any given day about 500 million barrels of crude oil and 100 million barrels of petroleum products are in-transit between producing and consuming regions.
- The efficient movement of this large volume of oil is achieved through the individual actions of numerous market participants.

CRUDE OIL—The major source of inter-regionally traded oil is the Middle East.

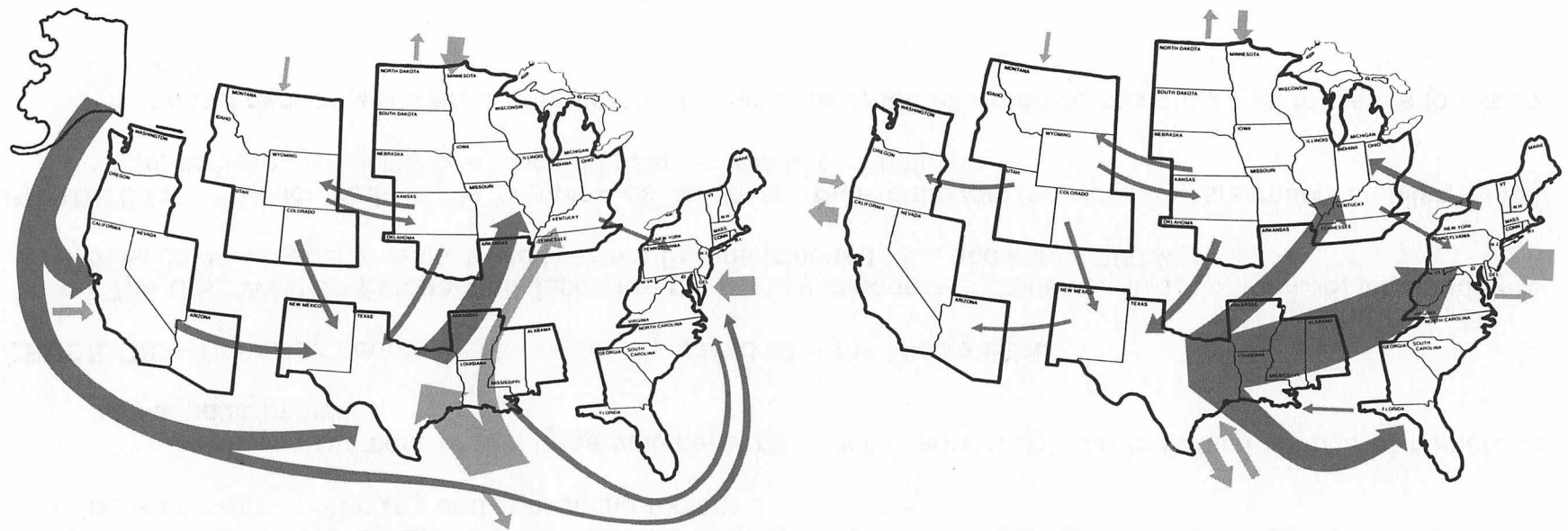
- The U.S., Western Europe, and Japan are the primary importers of crude oil. In 1990, the U.S. imported 44% of its crude oil requirements, while Western Europe imported 75% and Japan 100%.

PRODUCTS—Product trade is as complex as crude oil trade although the volumes are much smaller, since refineries have historically been located near centers of consumption.

- In the last decade world product trade has increased as crude oil exporting countries built refineries to export products.

CONCLUSION—*Events which impact supply or demand in any particular area of the world quickly affect the whole system. Price can be thought of as a communications network which drives individual actions in an optimal manner.*

U.S. PETROLEUM MARKETS REGIONAL INTERDEPENDENCE



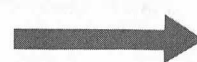
CRUDE OIL MOVEMENTS

PRODUCT MOVEMENTS

LEGEND



IMPORTS/EXPORTS



DOMESTIC SHIPPING

SOURCE: Data from Energy Information Administration.

U.S. PETROLEUM MARKETS REGIONAL INTERDEPENDENCE

OVERVIEW—As in the rest of the world, crude oil and petroleum products in the U.S. are commodities which are freely traded among different regions.

- Trade is based on individual decisions relating to supply and demand needs and is influenced by price.
- The petroleum markets have little linkage east and west of the Rockies except for Alaskan crude oil movements, primarily to the Gulf Coast.

CRUDE OIL—U.S. crude oil production falls far short of domestic refining requirements. In 1990, 44% of domestic crude oil runs were met by imports, which are a vital part of the system supply.

- The Gulf Coast and East Coast each receive large volumes of imported crude oil. Much of the volume received on the Gulf Coast is moved to the Midwest via pipeline.
- The West Coast is self-sufficient due to Alaskan production.

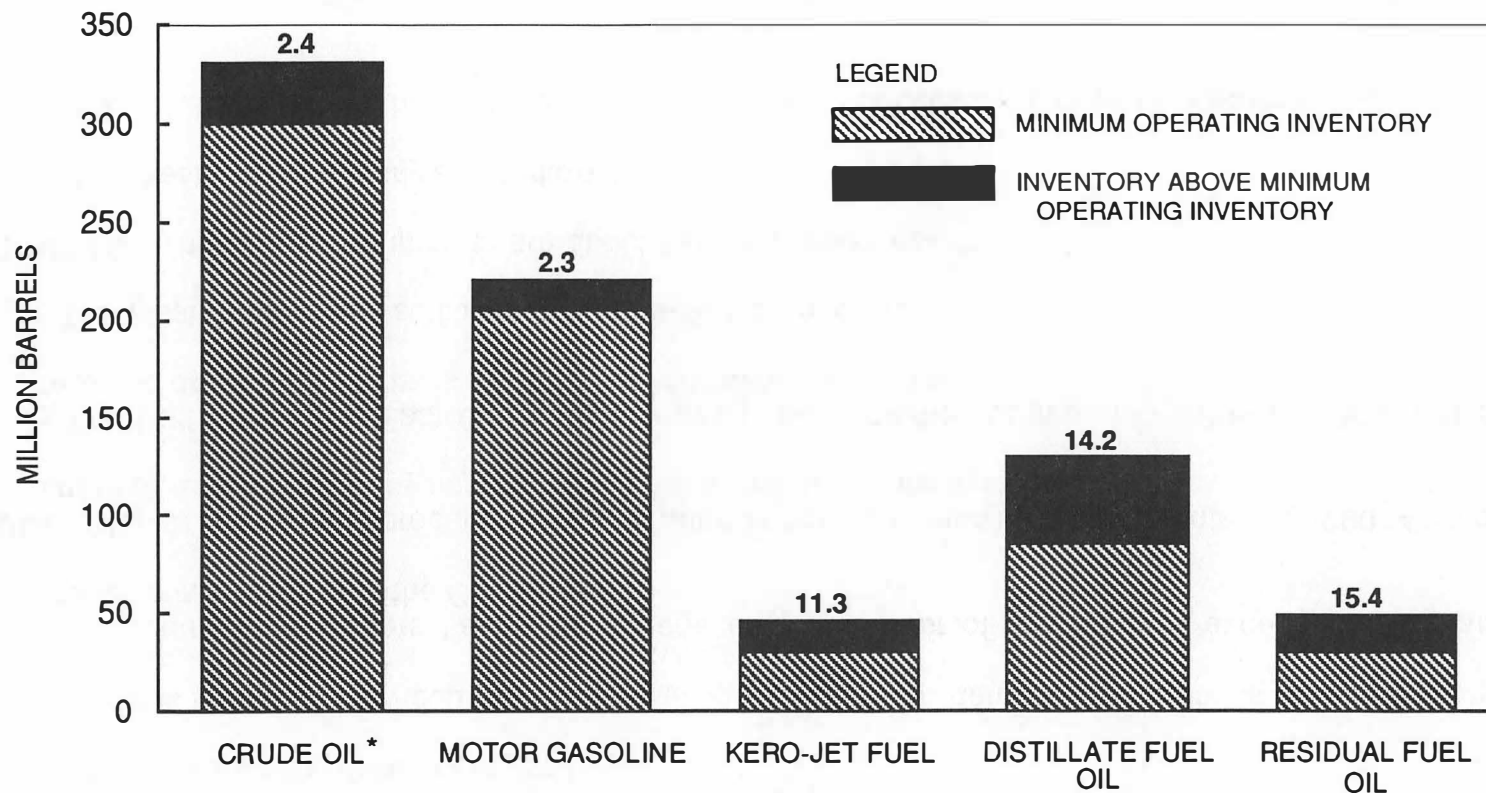
PRODUCTS—The U.S. gross imports are about 12% of product needs.

- The West Coast is nearly self-sufficient.
- East of the Rockies, the Gulf Coast refining center produces 57% of all petroleum products but consumes only 31%.
- The majority of product imports come into the Northeast, which represents about 61% of all U.S. imports of products.

CONCLUSION—*The U.S. depends on the rest of the world for about half of its petroleum supplies. The U.S. has a highly efficient distribution system based on supply volumes, demand needs, and prices, which allows crude oil and petroleum products to move from sources of production to the ultimate consumers.*

CRUDE OIL AND PRODUCT INVENTORIES KEY TO SYSTEM FLEXIBILITY

U.S. PRIMARY INVENTORIES—12/31/90



*Excludes SPR crude oil stocks of about 590 million barrels.

NOTES: Bold numbers are days' supply of inventory above minimum.

In addition, secondary and tertiary inventories provide surge capacity in event of disruptions.

SOURCE: Minimum operating inventories—NPC; inventories above minimum operating inventories—EIA.

CRUDE OIL AND PRODUCT INVENTORIES KEY TO SYSTEM FLEXIBILITY

OVERVIEW—The chart on the facing page shows inventories in the primary distribution system—at refineries, in the pipeline systems, and at distribution terminals.

- The system's flexibility depends on the volume of stocks above minimum operating inventories (MOI)—the level below which operating problems would begin to appear.
- The level of inventories can have a significant impact on oil prices; however, this relationship is not simple or straightforward. Prices are affected by expectations of future supply and demand in addition to the level of inventories in the current period.

PRIMARY—Inventories above MOI in the primary distribution system provide a cushion for refiners in the event of a supply disruption. However, in a disruption, rapid movement from primary stocks can give the perception of a supply shortfall.

- A seemingly low number of days' supply above minimum is not a concern in times of normal operations. In stress situations inventories can drop below MOI for short periods without significant dislocations, only increased operating costs. However, operations below minimum inventory levels cannot be sustained in the long run.

SECONDARY AND TERTIARY—Secondary and tertiary inventories provide critical operating flexibility during normal operations and some surge capacity during disruptions.

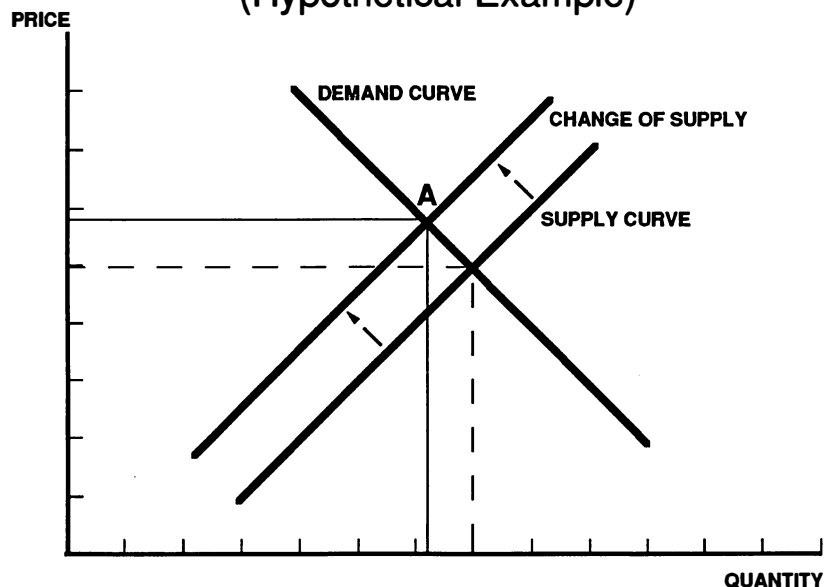
- Secondary inventories include stocks held at bulk plants and retail outlets.
- Tertiary inventories are those held in end-user storage.

CONCLUSION—*Crude oil and product inventories are made up of several types of stocks, each of which adds needed flexibility to the overall distribution system.*

THE FUNCTION OF PETROLEUM PRICES

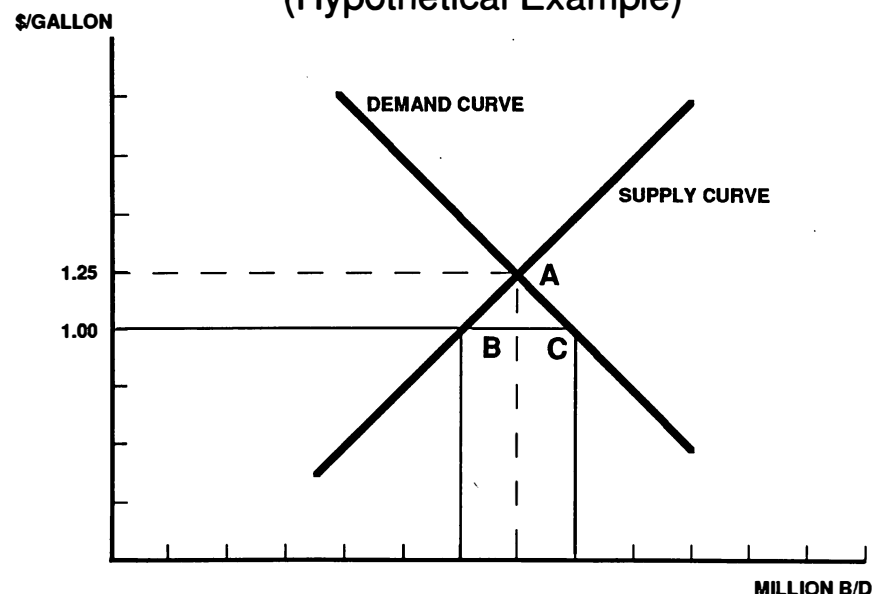
PRICES REACT SHARPLY TO CHANGES IN SUPPLY/DEMAND

HOW A CHANGE OF SUPPLY
AFFECTS PRICE
(Hypothetical Example)



The supply curve shows that suppliers of a good can economically provide more at higher prices, and less at lower prices. Conversely, buyers demand more at lower prices, while higher prices induce them to conserve and demand less, as shown by the demand curve. A loss of some supply means the remaining suppliers can provide less at any price level. This is expressed by a shift of the supply curve to the left, labeled "change of supply" here. The higher prices reduce the amount demanded, and a new "equilibrium" point (A), where supply and demand balance again, is required.

HOW ARTIFICAL PRICE RESTRICTIONS
CREATE SHORTAGES
(Hypothetical Example)



At point A on this graph, supply and demand are in balance at the price and quantity shown. If a lower price "ceiling" of \$1 per gallon occurs (through government mandate or "jaw-boning"), suppliers will not be able to supply more than the quantity corresponding to point B economically. However, consumers will conserve less and demand a greater quantity, corresponding to point C. The artificial price ceiling thus creates a shortage corresponding to the distance between points B and C. In oil markets, the demand and supply curves are always changing, resulting in continually changing prices.

THE FUNCTION OF PETROLEUM PRICES

PRICES REACT SHARPLY TO CHANGES IN SUPPLY/DEMAND

ECONOMICS—Price provides an essential driving force to balance the supply and the demand for oil (or for any good or service). As the price rises, it becomes economical to produce and supply more in the short term, while less can be provided economically if the price falls. A higher price also induces consumers to conserve or substitute other products, causing demand to fall. Conversely, at a lower price, consumers demand more.

- The market balances at a price at which buyers are willing to purchase the quantity of oil that suppliers are able to provide. If changes occur in the tastes or needs of buyers, or in the amount that suppliers are able to provide, the price must change to rebalance supply and demand.
- Expectations of future changes in supply and/or demand are just as important as volumes produced or consumed today in setting prices. The market continuously looks into the future to balance expected production and consumption, as well as today's supply and demand. A current or expected supply shortfall will induce buyers to bid up the price of available supplies. This calls forth additional supplies, either from output, inventory, or imports, while reducing demand.

APPLICATION TO OIL MARKETS—Oil prices are the result of the actions of many producing nations and competing large companies, thousands of small producers, tens of thousands of retailers, and millions of consuming organizations and individuals. Each participant's supply of, or demand for, oil is continuously changing and being re-evaluated. This results in rapid and frequent oil price changes, most of which are small.

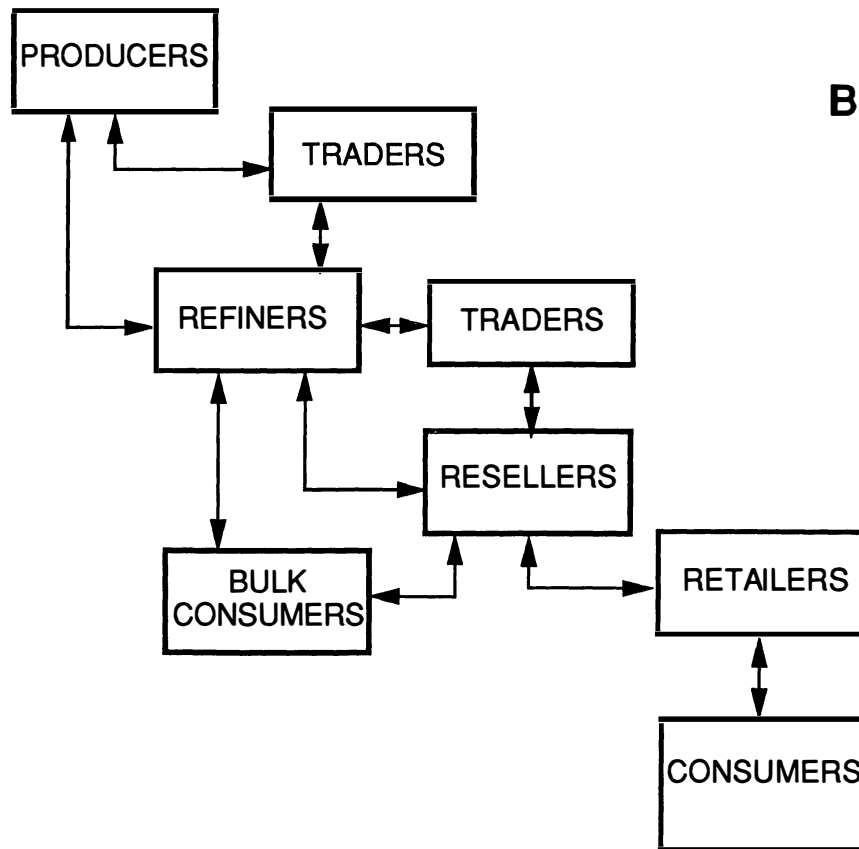
- Oil price changes rebalance supply and demand by encouraging changes in consumption; in the timing of purchases; in crude oil production; in refining volumes and product yields; and in imports, exports, and domestic logistics. The changes are always marginal, or incremental, involving only what can be altered most easily in the relevant time frame.
- Demands for most oil products have a relatively low elasticity, or responsiveness, to price changes in the short term. Thus, if sizeable demand changes are needed to rebalance the system, the price change needed to achieve this in the short term will be relatively large.

CONCLUSION—*Oil prices act to balance present and future oil supply and demand. Price controls distort this process. Any artificial interference in this process will distort the ability of this system to balance supply and demand.*

PETROLEUM PRICES

HOW PETROLEUM PRICE INFORMATION IS TRANSMITTED

Information flows
to and from all elements



BUYER/SELLER BASES DECISION ON:

- Own assessment
- Published price estimates
- Electronic information services
- Futures prices

PETROLEUM PRICES

HOW PETROLEUM PRICE INFORMATION IS TRANSMITTED

OVERVIEW—Information on price and markets (retail, wholesale, and cargo) are sent from and to all elements of the distribution chain, from producers to consumers. All buyers and sellers have at least some information about the supply/demand balance and competitive prices: the driver sees gasoline prices posted in foot-high letters in his town; the heating oil consumer talks to his neighbors. Petroleum industry participants in broader markets have access to additional information, as well, so that there is more and more information available as one moves from retail product consumer back to the crude oil producer.

SPOT PRICES—Spot prices for single transactions of physical volumes provide the industry with rapid signals of changes in supply and demand, and the petroleum market makes constant adjustments to move supplies of crude oil and petroleum product from oversupplied regions and companies to those needing supply. Spot prices and other market-related prices also influence the price for contract volumes.

PRICE PUBLICATIONS—Print trade publications provide daily and weekly estimates of spot prices in cash (physical volume) markets, based on contacts with industry participants in the cash trade. Spot prices are published for various commodities, including quality distinctions, and for various locations. For instance, petroleum products are traded in Northwest Europe, the Mediterranean, Singapore, the Caribbean, the U.S. Gulf Coast, the U.S. East Coast, and the U.S. West Coast. Price information on gasolines is available for each of these regional centers. Price data for crude oils, generally at the point of loading, are also available for different crude oil streams and various delivery periods. In assessing these markets, the trade publications take into consideration many transactions.

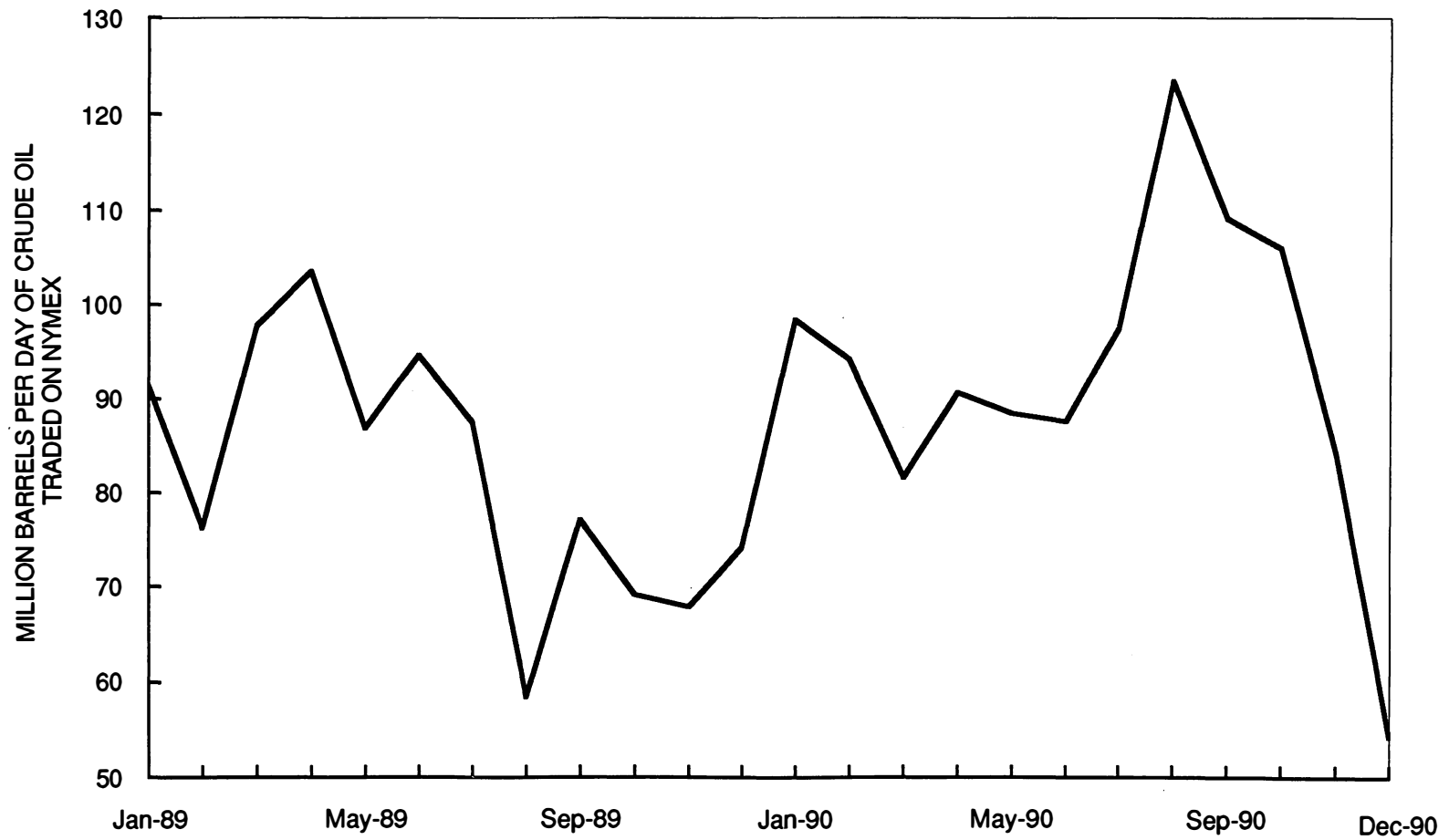
THE FUTURES MARKETS—New York Mercantile Exchange, International Petroleum Exchange, and Singapore Mercantile Exchange provide moment-to-moment information on oil prices throughout the day. Price information is therefore based on thousands of transactions every day.

CONCLUSION—*Petroleum is a commodity traded on a worldwide basis. The methods of contractual agreements between buyer and seller are wide ranging and are immaterial to the commercial value of the crude oil at any one point in time. The value of this crude oil is reflected in its price, which is generated and transmitted by all elements in the distribution chain. Price changes are a result of thousands of individual competitive decisions.*

FUTURES MARKETS

PRICE TRANSPARENCY AND REDUCED PRICE RISKS

HIGH LIQUIDITY MAKES THE NYMEX A RELIABLE SOURCE OF PRICE INFORMATION



NOTE: At lot sizes of 10-20 contracts, 10,000 transactions take place daily.

SOURCE: New York Mercantile Exchange.

FUTURES MARKETS

PRICE TRANSPARENCY AND REDUCED PRICE RISKS

OVERVIEW—Each of the energy futures markets provides price transparency and a mechanism to reduce risk. A commodity futures contract is a standardized "paper" contract which calls for the future delivery of specified quantities of a specified commodity at a specified place, price, and time in the future.

NYMEX—The only U.S.-based futures market with energy contracts is the New York Mercantile Exchange (NYMEX). A government-regulated entity, NYMEX trades contracts in crude oil, heating oil, regular unleaded gasoline, propane, residual fuel oil, and natural gas.

VOLUME—The crude oil contract, which has the highest volume, traded an average of 100,000 contracts (100 million barrels) each day in recent months, or 6 times the daily total consumption of oil in the U.S. This daily volume is accomplished in approximately 10,000 transactions.

PRICE DISCOVERY—These many transactions provide critical price discovery for petroleum markets. Since the current trading price is instantaneously available, any participant can evaluate a prospective transaction at any time of the trading day. In earlier times, trade publications' assessments of spot prices were available only on a daily basis.

HEDGING—The markets also provide an opportunity to shift risk. The uncertainty presented by fluctuating prices introduces risk into decisions. (Without volatility in the cash market, hedging is unnecessary.) Hedging can reduce that risk by locking in prices. The NYMEX's crude oil contracts in recent months have mainly been held by firms with commercial needs for physical volumes.

ALTERNATIVE SOURCE—While the NYMEX provides an alternative source of physical supply, it is designed as a financial instrument. For the most actively traded contracts—crude oil, heating oil, and gasoline—deliveries, including exchanges, equal less than 1% of the traded volume.

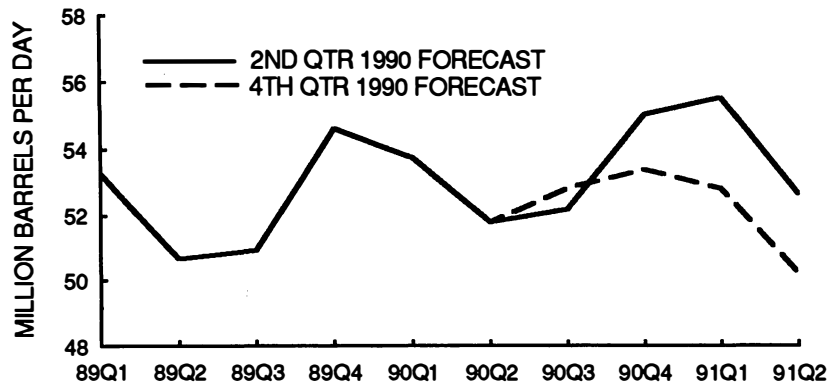
INVENTORIES—Price moves in futures markets also signal the advisability of holding or liquidating inventory. Since the Iraqi invasion, futures prices have suggested that inventories would be less valuable in the future, hence discouraging hoarding supplies and encouraging drawing inventories down, precisely the pattern most calming for a nervous market.

REGULATION—Under current rules, a substantial regulatory framework exists to correct imbalances or dysfunctions in the futures market, such as increasing deliveries, suspending trading, and limiting price moves in the current month.

CONCLUSION—*The futures market has become highly integrated with the dynamic oil markets. The futures market provides for price discovery and a mechanism to reduce risk. In addition, it has become a widely used price clearinghouse to effect wet-barrel transactions through the exchange for physicals procedure. Closing the NYMEX in an emergency would be disruptive.*

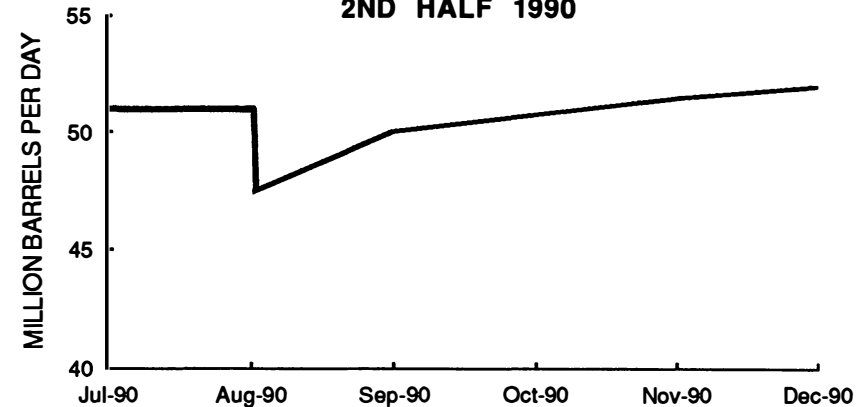
WORLDWIDE IMPACT OF IRAQ INVASION/U.N. EMBARGO LOST SUPPLY, HIGHER PRICES, LOWER DEMAND

**TOTAL MARKET ECONOMIES' OIL DEMAND—
APRIL 1990 AND 4TH QUARTER 1990 EIA FORECASTS**



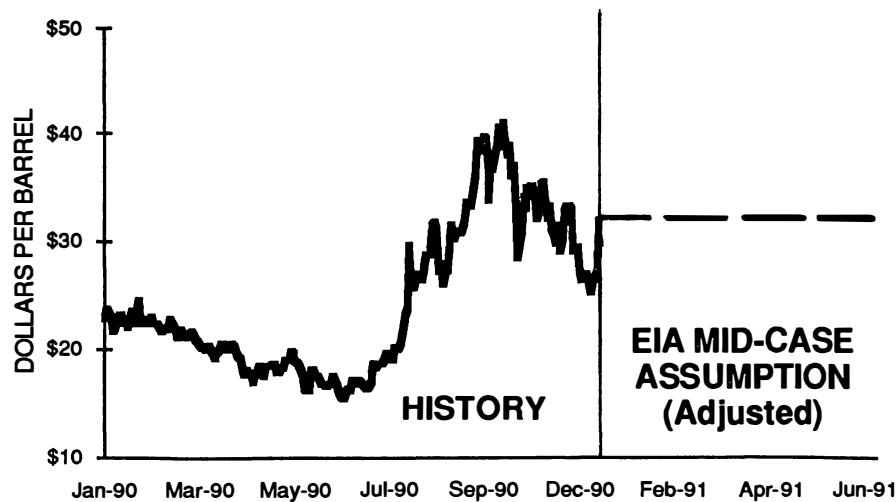
SOURCE: EIA *Short-Term Energy Outlook*, Second and Fourth Quarters.

**WORLD CRUDE OIL PRODUCTION—
2ND HALF 1990**



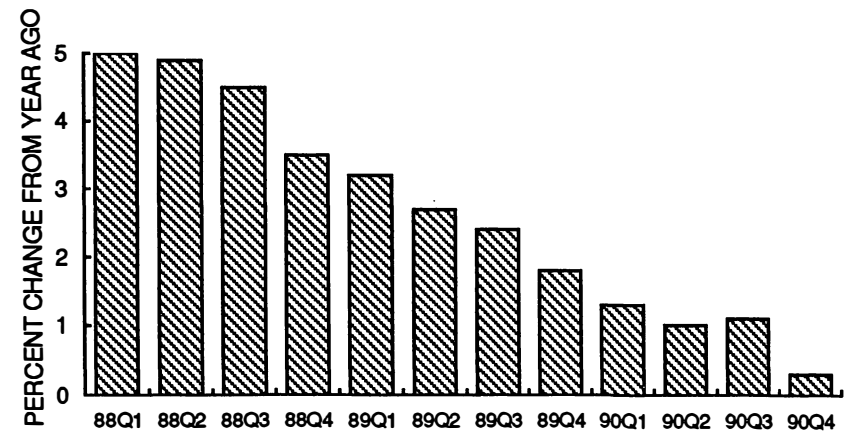
SOURCE: Data from *Petroleum Intelligence Weekly*.

SPOT PRICE OF CRUDE OIL—WEST TEXAS INTERMEDIATE



SOURCES: History from Platt's. Price projection is the \$30 case from EIA 1990 *Fourth Quarter Short-Term Energy Outlook*, adjusted for typical crude oil quality differential.

GROSS NATIONAL PRODUCT



SOURCE: Wharton Econometrics Estimate.

WORLDWIDE IMPACT OF IRAQI INVASION/U.N. EMBARGO

LOST SUPPLY, HIGHER PRICES, LOWER DEMAND

SUPPLY—The Iraqi invasion cut off 1.3 million barrels per day of Kuwaiti crude oil and refined products exports to the world. Soon thereafter, the U.N. embargo slashed world oil supplies by another 3 million barrels per day by cutting off Iraqi exports.

- Other oil producing countries have raised output since August 2, by a combined amount which slightly exceeds the fall in Iraqi and Kuwaiti output. There was a mix of economic, technical, and political grounds for these increases. Saudi Arabia alone accounts for more than half of the rise in output, having boosted production further and faster than generally expected. However, the total increase has used up most current oil production capacity. (See subsequent chart "Further World System Stress—Little Flexibility to Handle Production Loss.")

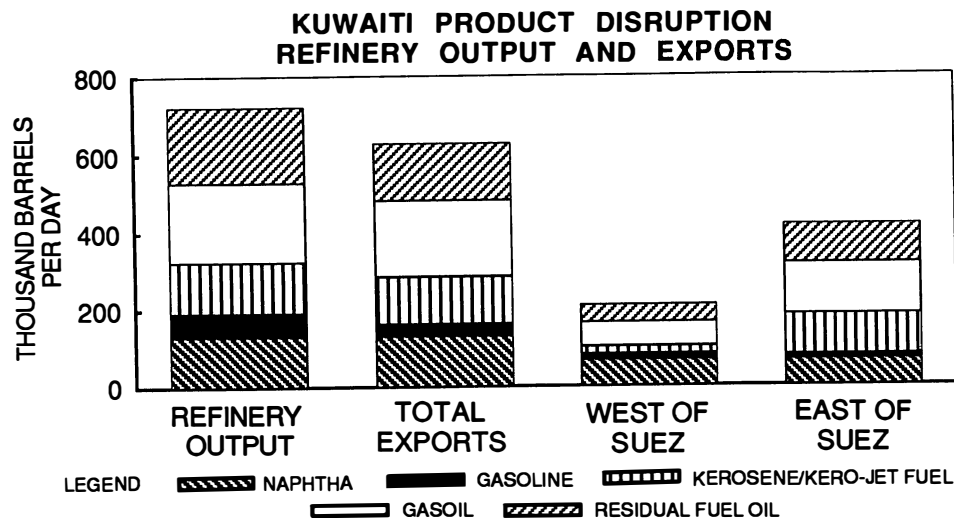
PRICE—The imbalance of supply and demand boosted oil prices substantially. Market expectations of further supply disruptions from hostilities in the Persian Gulf have also acted to support the price of oil.

- Price increases induced consumers throughout the world to conserve oil, thus helping to bring winter supply and demand back into balance.

DEMAND—The increased price of oil has brought about substantial reductions in oil demand. In addition, economic growth has been trending downward for two years, and this weakening growth has helped reduce oil consumption.

CONCLUSION—*The Iraqi invasion and the subsequent U.N. embargo seriously disrupted the world supply/demand balance initially. The balance has been restored, and the increase in the price of oil played a crucial role in this process.*

CURRENT SYSTEM CAPABILITY THE DISRUPTION TO KUWAITI REFINING AND WORLD REFINING CAPACITY

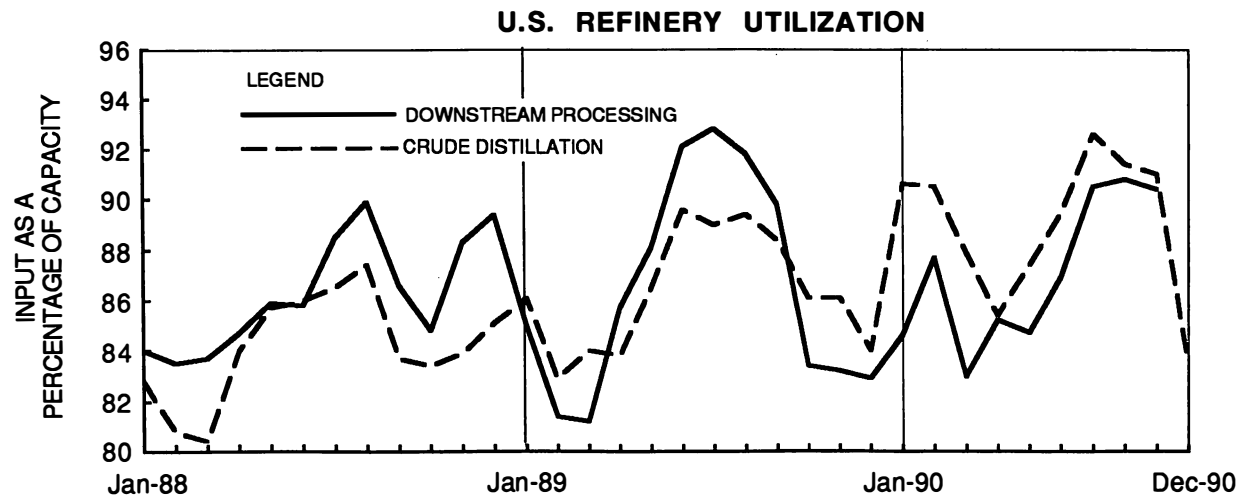


SOURCE: Energy Security Analysis, Inc.

REPLACEMENT OF KUWAITI PRODUCT EXPORTS

Most of the product exported by Kuwait prior to the August invasion went "East of Suez" to Japan and Asian LDC's. These lost barrels were replaced by the following:

1. Most of the lost Kuwaiti product exports were made up through increases in refinery throughput in Saudi Arabia and Japan.
2. Somewhat weaker demand in Asia after the August invasion lessened the impact of the Kuwaiti product disruption.
3. Following the August invasion, additional barrels of middle distillates were moved into the Asia-Pacific region from as far away as Europe.



NOTE: Downstream processing includes catalytic cracking and coking.

SOURCE: U.S. Department of Energy, *Oil and Gas Journal*, Energy Security Analysis, Inc.

CURRENT SYSTEM CAPABILITY

THE DISRUPTION TO KUWAITI REFINING AND WORLD REFINING CAPACITY

WORLD CAPACITY—There is surplus refining capacity in the world, although most of it is relatively simple crude oil distillation capacity. Compared with the rest of the world, the U.S. has relatively sophisticated refining capacity. (Sophistication is roughly measured as downstream processing capacity as a percent of distillation capacity.) (See subsequent chart: "Further System Stress—World Refining Capacity Is Adequate.")

KUWAITI LOSS—As described above, the loss of the Kuwaiti refining sector (approx. 700 thousand barrels per day of crude oil throughput) was managed primarily through increases in refinery throughput in Saudi Arabia and Japan. The spare capacity used in Japan (and to some degree in Saudi Arabia) is relatively unsophisticated; therefore, on average, fewer barrels of light products are made from each barrel of crude oil input than would be the case in the Kuwaiti refineries.

DESERT SHIELD DEMANDS—The increase in demand for middle distillates (jet fuel, diesel) associated with Operation Desert Shield has also been partly managed through greater refinery output in Saudi Arabia.

CONCLUSION—*Even with the loss of Kuwaiti refining, the world's refining sector has had enough flexibility to make up the shortfall. However, due to the lack of downstream processing worldwide, if additional sophisticated capacity is lost, there is limited remaining response capability.*

U.S. REFINING CAPACITY

CAPACITY—The U.S., as a refining sector, has little spare crude oil distillation capacity, especially during peak demand periods. The U.S. has even less spare downstream processing capacity. As shown in the U.S. Refinery Utilization graph on the facing page, during the peak gasoline demand period, there is essentially no spare downstream processing capacity in the U.S. This is especially true in PADDs I, II, and III.

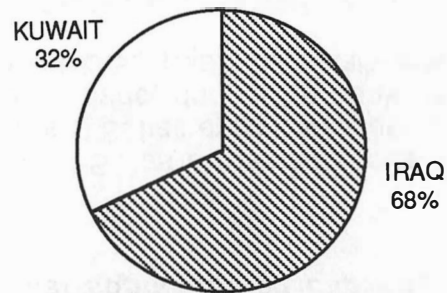
SHUTDOWNS—During a weak demand period, the U.S. system has some flexibility to handle modest refining capacity shutdowns in the U.S. Given the extensive domestic distribution system, refinery outages would not likely result in regional supply imbalances. However, given that U.S. downstream processing capacity is highly utilized, the capability to produce transportation products would be impacted more.

CONCLUSION—*The U.S. refining sector is flexible enough to adapt to modest product supply disruptions. In the event of significant disruptions, spare refining capacity in other countries can supplement the U.S. market. Depending on the relative supply of product, U.S. product prices may have to rise significantly to attract incremental supply.*

CURRENT SYSTEM CAPABILITY

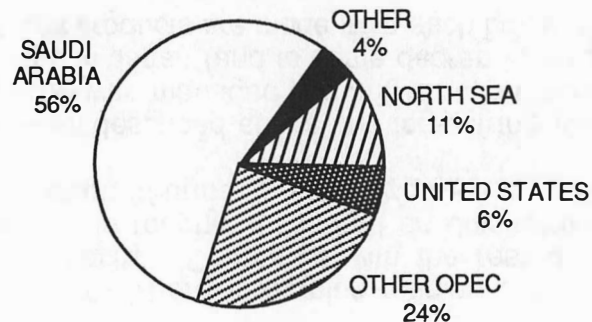
CRUDE OIL QUALITY, LOGISTICS, AND FUEL SWITCHING

CRUDE OIL QUALITY LOSS



33.3° API AVERAGE
2.25% SULFUR AVERAGE

REPLACEMENT



30.0° API AVERAGE
1.85% SULFUR AVERAGE

LOGISTICS

U.S. pipeline systems are resilient and flexible to handle most disruptions.

There is little spare capacity in the U.S. tanker fleet.

The propane distribution system from wellhead to consumer is efficient, but operates at near capacity in winter.

FUEL SWITCHING

Significant fuel switching capacity is not available.

CURRENT SYSTEM CAPABILITY

CRUDE OIL QUALITY, LOGISTICS, AND FUEL SWITCHING

OVERVIEW—Current crude oil quality can be handled with minor changes in trading patterns and product yield.

- The U.S. logistics system retains its historical flexibility.
- Fuel switching offers little opportunity to reduce oil consumption.

CRUDE OIL QUALITY—The NPC believes that individual refinery problems with crude oil quality will be minor and solved by trading, if necessary.

- The crude oils replacing the lost Kuwaiti/Iraqi crude oils were on average about 3° API heavier and 0.4% lower in sulfur. The impact on average world supply was a decrease of 0.3° API (heavier), which may have yielded 100-150 thousand barrels per day of residual fuel oil at the expense of light products.
- Heavier replacement crude oil can be handled within the U.S. refinery system, which has logistical capacity for the additional residual fuel oil production.

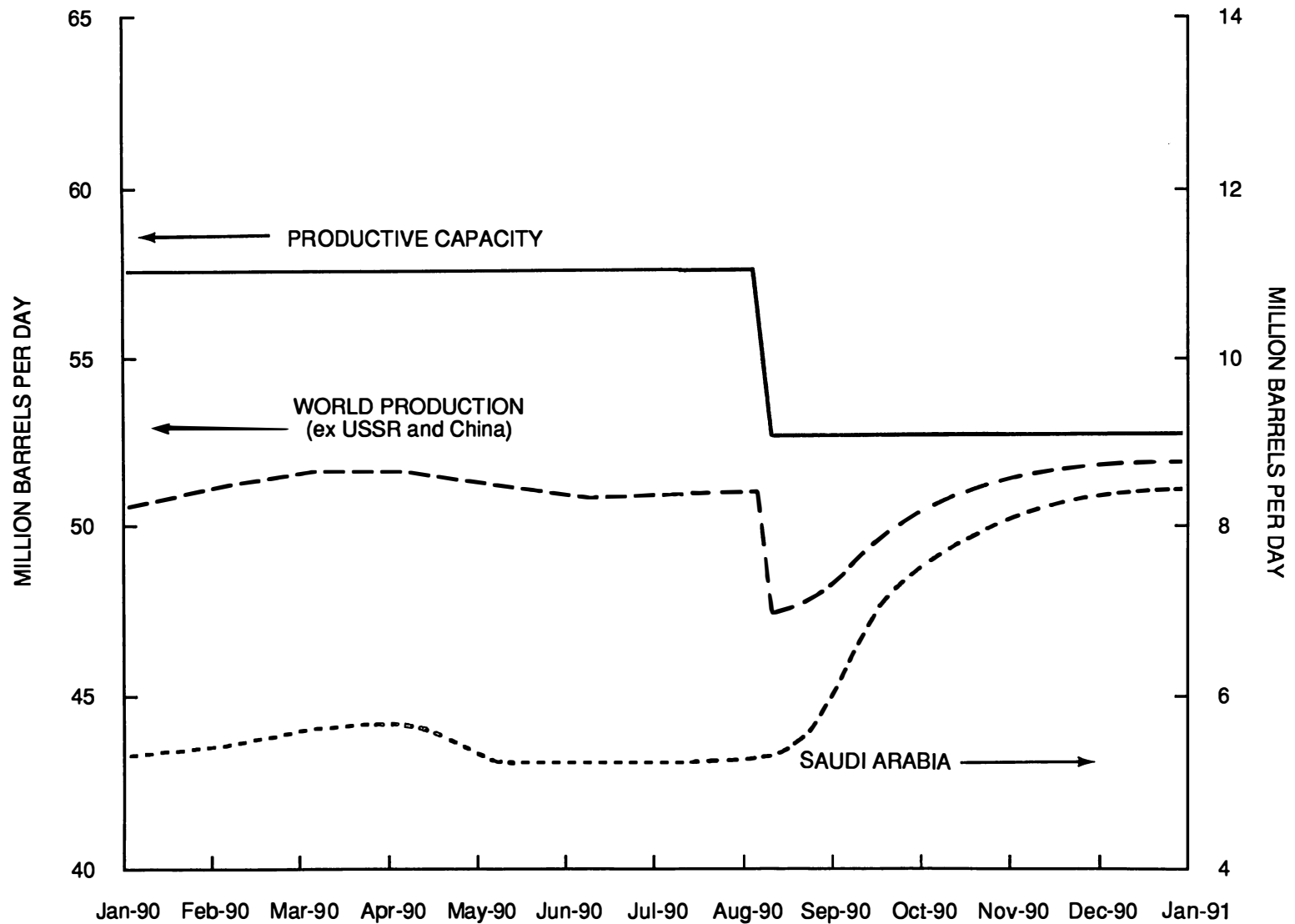
LOGISTICS—Potential problems in the Northeast due to a greater reliance on foreign imports and supplies from the U.S. Gulf Coast.

- U.S. pipeline systems have historically responded to changing needs for both products and crude oil. The interconnectability of the individual parts of the system permits shifting and diverting product from many sources to virtually any point of ultimate consumption.
- U.S. tanker fleet (Jones Act) is projected to be adequate to cover current demands under normal operating conditions, but little spare capacity remains. However, there is concern that some states' unlimited oil spill liability provisions may cause shippers to refuse to take tankers into U.S. ports.

FUEL SWITCHING—The NPC estimates that at the time of the invasion of Kuwait, most significant switching to gas had already taken place due to economics.

CONCLUSION—*A measurable change in worldwide crude oil gravity has occurred, while crude oil sulfur content has marginally improved. Although yields have shifted toward residual fuel oil, overall impact is estimated to be minimal. The change directionally contributes to system constraints on refinery processing limits and the ability to make light products. The U.S. logistical system retains its ability to respond under the current situation. Fuel switching is not a significant issue.*

FURTHER WORLD SYSTEM STRESS LITTLE FLEXIBILITY TO HANDLE PRODUCTION LOSS



SOURCE: Data from *Petroleum Intelligence Weekly*.

FURTHER WORLD SYSTEM STRESS LITTLE FLEXIBILITY TO HANDLE PRODUCTION LOSS

BACKGROUND—At the end of 1990, there was essentially no surplus short-term crude oil production capability remaining in the world.

- Increased crude oil production from Persian Gulf countries (excluding Iraq and Kuwait) is critical to world oil supply, and more at risk of disruption than any other single component.
- Any additional adjustments that must be made due to a production loss must come from reduced demand and/or drawdown of worldwide strategic stocks.

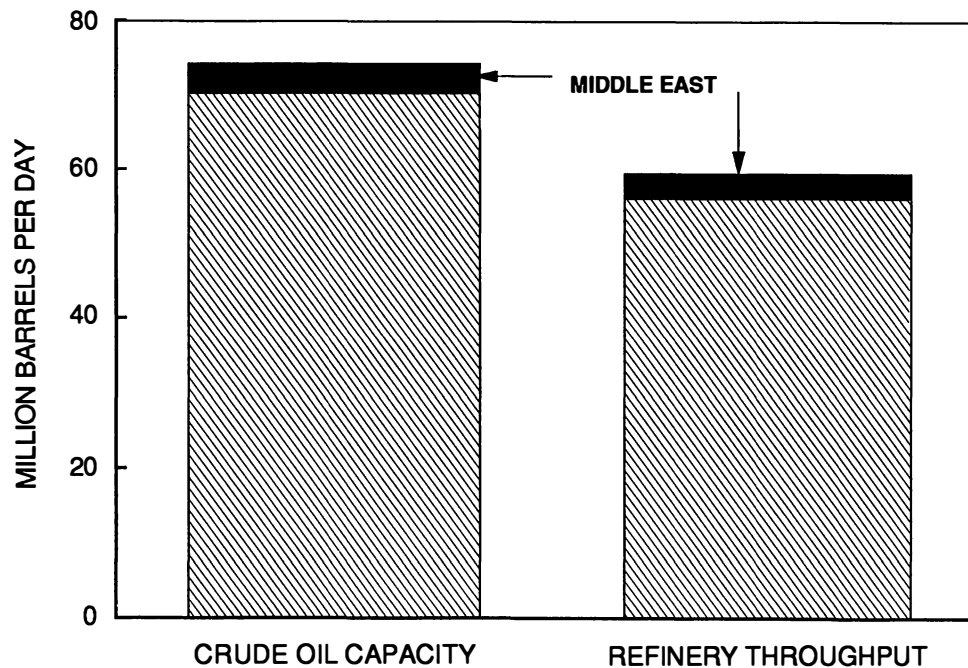
ADJUSTMENT TO THE ADDED STRESS—Due to the low price elasticity of oil demand in the short term, rapid and large price rises will bring supply and demand back into balance if there was an additional substantial loss of production.

- Consumers and marketers would compete for the remaining available supplies, bidding up prices.
- The extent of the necessary demand reduction and resultant price rise will depend on the magnitude and speed of strategic stock drawdowns.

CONCLUSION—*Since essentially no additional short-term world crude oil production capability is available, any additional loss of production must be made up by demand declines or strategic stock draws. A rapid, large price rise is to be expected, especially if strategic stocks are not drawn.*

FURTHER SYSTEM STRESS WORLD REFINING CAPACITY IS ADEQUATE

World Refining Capacity
and Throughput, 1989



World refining capacity
is surplus.

Middle East refining
capacity, if lost,
can be made up.

NOTE: Worldwide refinery utilization averaged 80% in 1989.

SOURCE: BP Statistical Report of the World Oil Industry.

FURTHER SYSTEM STRESS

WORLD REFINING CAPACITY IS ADEQUATE

OVERVIEW—World refining capacity is surplus today, and is expected to remain so even beyond the period under study.

UTILIZATION—On average, worldwide refineries ran at 80% capacity utilization in 1989. Among the major refining regions, the highest utilization was in the United States, while regions with less sophisticated capacity generally ran at lower utilization. Japan, for instance, ran its refineries at about 75% in 1989. Thus, even with higher throughputs to make up for the lost Kuwaiti capacity, Japan's facilities remain underutilized.

MIDDLE EAST—Middle Eastern refining capacity outside of Iraq and Kuwait totals about 3.5 million barrels per day, half of which is in Saudi Arabia. (About half of the Saudi capacity is located on the Red Sea, 750 miles across the peninsula from the Persian Gulf.) The Middle East capacity is relatively unsophisticated, in comparison to the Kuwaiti capacity or to the U.S. refining industry. However, if crude oil is available, additional throughputs at other refineries can help offset the loss of Middle East refinery capacity.

- It is unlikely that Middle East refining capacity would be lost while the region's crude oil continues to flow unimpeded. If both the capacity and the crude oil supplies are shut down, of course, refining capacity will not be constrained.

DESERT SHIELD DEMANDS—Although data are classified, Saudi Arabia has been supplying fuel for Saudi-based troops in Operation Desert Shield. So far, actual consumption of fuel has been a minor part of world trade; through mid-December, the Operation has consumed about 100 thousand barrels per day of all types of fuels, both in Saudi Arabia and in other Middle East staging points. (This is not all incremental to world demand, and includes vessel bunkers as well as gasoline and jet fuel.)

- Jet fuel will pose the largest problem if the Saudi refineries are unable to supply it during an armed conflict. Estimates of likely consumption during a war are strictly classified. Surplus refining capacity and product tankers throughout the world lead the NPC to conclude that under most conditions product can be replaced from other sources. Such an occurrence, however, could involve supply dislocations while the system rebalanced, and thus higher product prices and higher transportation rates.

CONCLUSION—*World refining capacity is not a constraint even with a large loss of capacity. The logistics system has additional flexibility to replace supplies, if necessary, for military operations in the Middle East.*

FURTHER SYSTEM STRESS

DOMESTIC ISSUES—CRUDE OIL SUPPLY LOSS

REFINERY UTILIZATION AND FLEXIBILITY—The U.S. refinery industry is currently operating at about 85% of primary distillation capacity. The unused capacity allows the industry some flexibility to meet additional stresses.

- Since the world system cannot generate additional crude oil supply if there is a severe disruption, early and quick release of Strategic Petroleum Reserve (SPR) oil is necessary. Ideally, this action would be in conjunction with the release of other International Energy Agency strategic stocks, but the decision to offer SPR oil for bid should not be contingent on international agreement.

WORLDWIDE MARKETS WILL REBALANCE PRODUCT FLOWS—Economics and the free market drive the system. As crude oil supply shortages develop, prices rise, encouraging a shift to rebalance the disposition of oil products, gas, and other forms of energy.

- U.S. government actions to restrain prices will keep demand higher than it would be otherwise. (See previous chart: "The Function of Petroleum Prices.") This would also reduce our competitiveness in bidding for crude oil in the world market.

GOVERNMENT OPTIONS TO INCREASE PRODUCT SUPPLY—A temporary waiver on Reid Vapor Pressure (RVP) regulations would allow the industry to blend additional volumes of butane into gasoline, which would increase gasoline supplies at the expense of chemical feedstocks.

- Domestic logistics should not be limiting. Rebalancing of domestic crude oil production and SPR draw will require prompt Jones Act waivers.

CONCLUSION—*The system has the capacity and ability to deliver product, provided artificial restraints are not placed upon it. A crude oil loss is the major problem facing the industry, because world crude oil production is operating at capacity.*

FURTHER SYSTEM STRESS
DOMESTIC REGIONAL ISSUES—FACILITY SHUTDOWNS OR COLD WEATHER

REFINERY SHUTDOWN—Isolated refinery disruptions, even in relatively large and sophisticated plants, is unlikely to result in physical shortages. It is, however, important to note that in spite of the overall adequacy of refinery capacity, the loss of several major sophisticated refineries could cause regional problems.

- There would be some short-term regional dislocation until the system readjusted. Major unanticipated refinery shutdowns in isolated areas (Northeast, Midcontinent, West Coast) would cause price spikes before the system rebalances.

PIPELINE SHUTDOWN—The shutdowns of Plantation or Colonial pipelines would cause temporary terminal outages in the Southeast and East Coast markets. The loss of Explorer pipeline would have the same effect on the Midwest. If pipeline repairs could not be completed in a few days, the lack of Jones Act tankers would slow the domestic rebalancing.

CONCLUSION—*The distribution system is flexible and can respond quickly to supply disruptions. Only in extreme cases would outages occur. These outages would be localized and quickly alleviated through product reallocation due to free market pricing.*

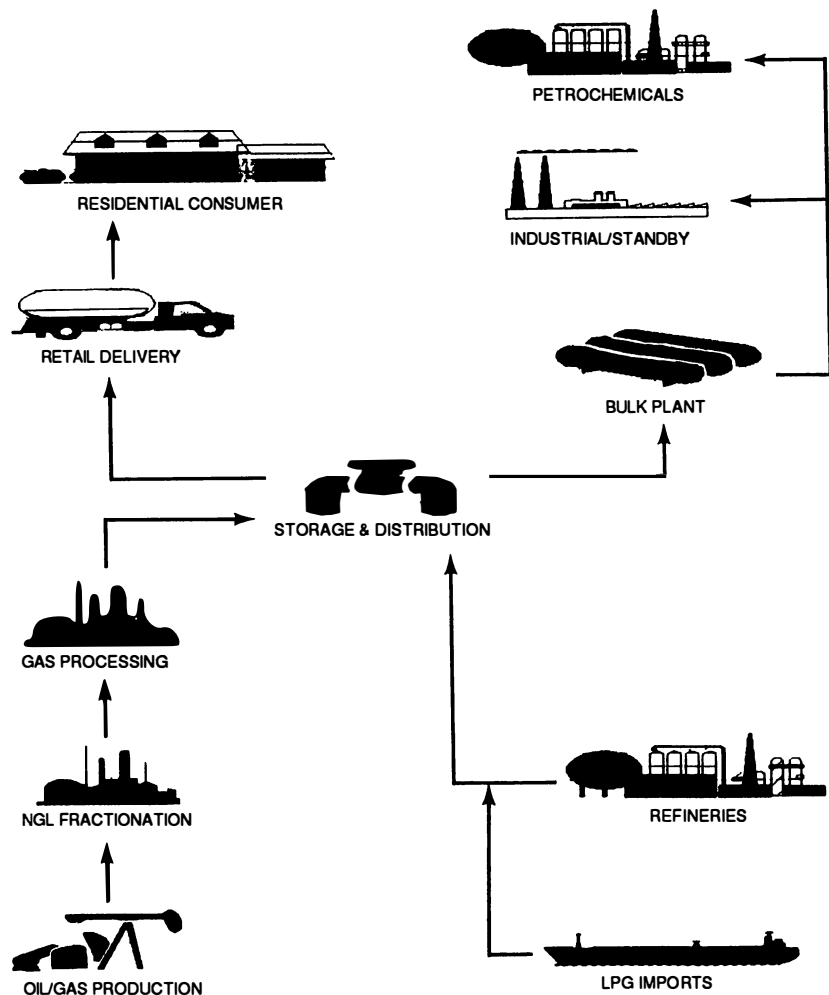
COLD WEATHER—In the winter freeze of December 1989 a number of U.S. Gulf Coast refineries were damaged, and a short-term shortage developed. The distribution system was taxed, but this is not unusual in times of demand surges. The system responded to the temporary imbalance between supply and demand through higher prices, quickly followed by increased supply and lower prices. This rebalancing was significantly helped by moderation in the cold weather.

- In the event of a major supply disruption (caused by extremely cold weather), government action may be necessary to address public health and safety issues. One government response would be to expedite the processing of LIHEAP (Low Income Home Energy Assistance Program) funds to assist those unable to make home heating payments.
- Governmental controls are not the answer to problems, because these stop the rebalancing mechanism and create artificial supply/demand balances.

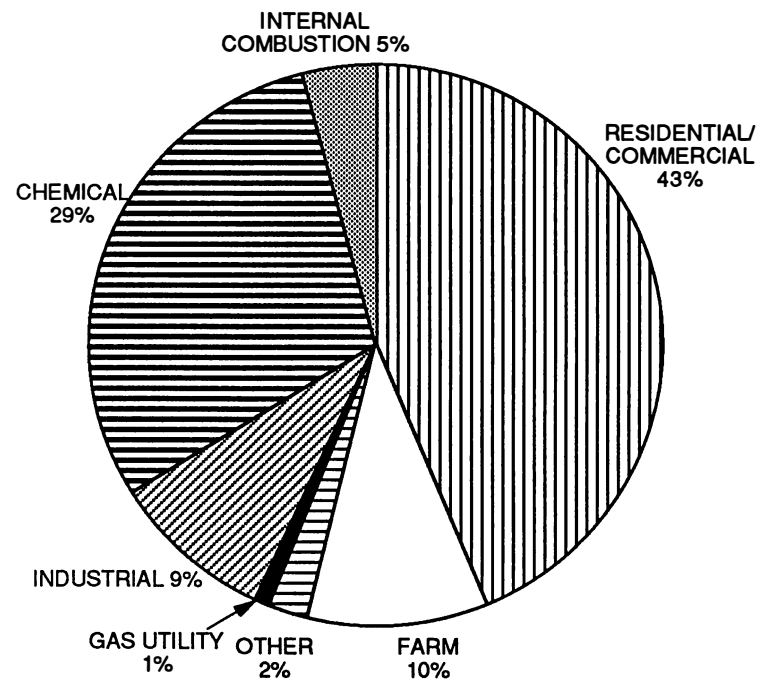
CONCLUSION—*The market is efficient. History has demonstrated that there is sufficient flexibility for the system to rebalance. Government LIHEAP funds should be released early.*

FURTHER SYSTEM STRESS DOMESTIC REGIONAL ISSUES—PROPANE

PROPANE/PROPYLENE SUPPLY/DEMAND CHAIN



END-USE PROPANE/PROPYLENE DEMAND



SOURCE: *Sales of Natural Gas Liquids and Liquefied Refinery Gases*, American Petroleum Institute, 1988.

FURTHER SYSTEM STRESS

DOMESTIC REGIONAL ISSUES—PROPANE

OVERVIEW—Propane/propylene demand (990 thousand barrels per day) constitutes 6% of the demand for all products in the U.S.

- Direct fuel burning accounts for 71% of propane/propylene demand.
- Chemicals consume the remaining 29%—only chemical plants and refiners consume propylene (130 thousand barrels per day).
- Residential, commercial, and farm sectors account for 53% of all sales.
- Domestic propane/propylene product supply (% of total)—Natural gas plants account for 49% of the supply, refineries 41%, and imports 10%. Domestic supplies augmented by imports into the East Coast are adequate to meet demand.

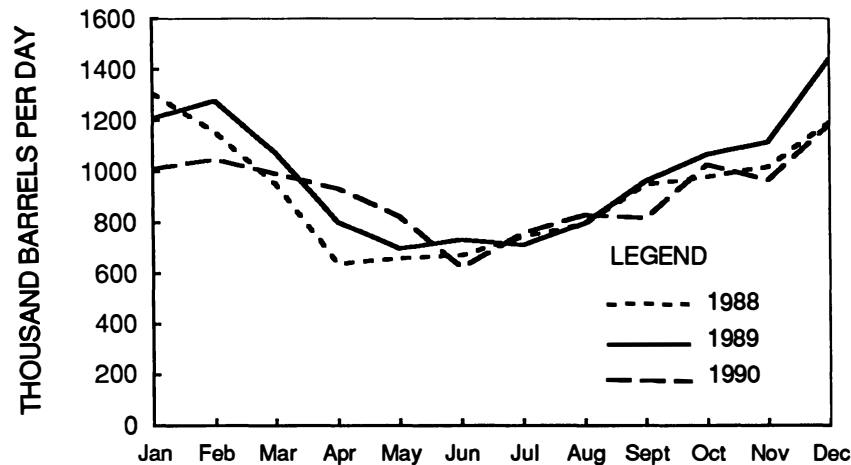
DISTRIBUTION SYSTEM—East of the Rockies, most of the propane/propylene supply is from natural gas plants and refineries in the Gulf Coast while most of the demand is in the Midwest and East Coast.

- Distribution is primarily via two major pipeline systems from the Gulf Coast—one serving the Midwest and the Northeast, the other serving the Southeast.
- Capacity is adequate on average, but delivery systems may be constrained during winter month peak demands.
- During peak demand periods, ocean transportation may be required to move supplies to the East Coast from the Gulf Coast—only one U.S.-flag propane tanker.

CONCLUSION—*The distribution system from wellhead to consumer is efficient, but operates at near capacity in winter. The system is taxed during periods of unusual demand surges such as occurred in December 1989.*

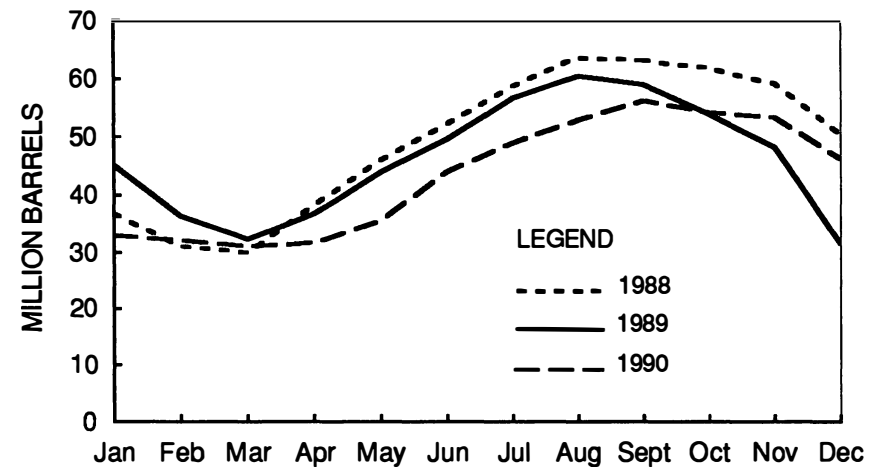
FURTHER SYSTEM STRESS DOMESTIC REGIONAL ISSUES—PROPANE

U.S. DOMESTIC DEMAND
FOR PROPANE/PROPYLENE



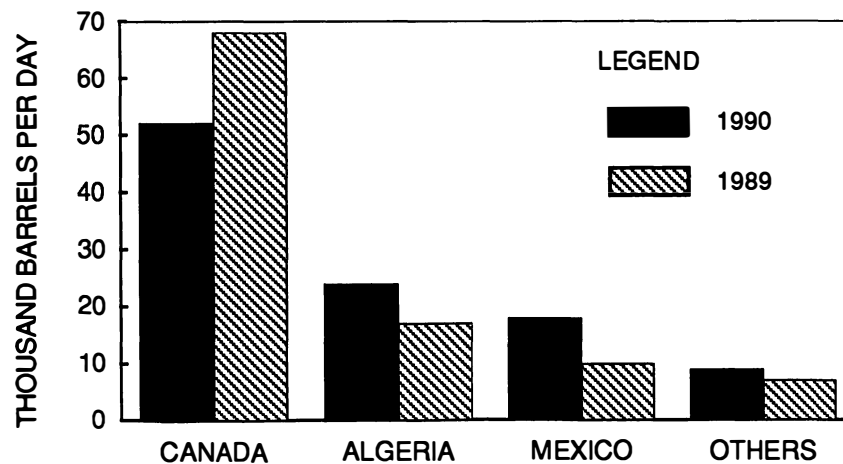
SOURCE: EIA Petroleum Supply Monthly.

U.S. INVENTORIES
OF PROPANE/ PROPYLENE



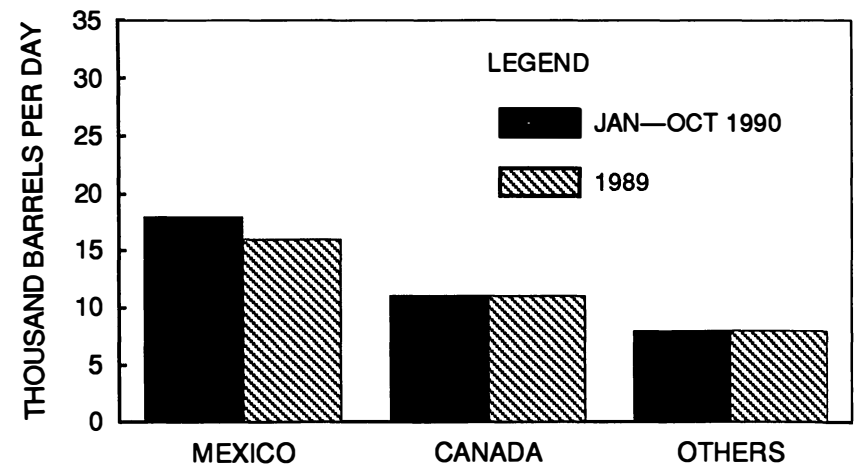
SOURCE: EIA Petroleum Supply Monthly.

U.S. PROPANE IMPORTS BY COUNTRY OF ORIGIN



SOURCE: Phillips Petroleum.

U.S. LPG EXPORTS BY DESTINATION



SOURCE: EIA Petroleum Supply Monthly.

FURTHER SYSTEM STRESS DOMESTIC REGIONAL ISSUES—PROPANE

SUPPLY/DEMAND

- Demand is seasonal and weather related—weather in December 1989 (coldest ever) was 28% colder than normal and demand averaged 1,439 thousand barrels per day, up 21% from the previous year.
- 1990 inventories started low but ended the year above 1989 levels.
- U.S. propane imports—Canada and Mexico are secure supply sources, with Algeria growing in importance. Persian Gulf imports into the U.S. are less than 5 thousand barrels per day.
- U.S. exports of propane/propylene in 1990 are estimated to be about 25 thousand barrels per day.

GOVERNMENT RESPONSES TO A SUPPLY INTERRUPTION

- Encourage fuel switching to natural gas—Higher gas production would increase throughput at natural gas plants, leading to higher propane supply. Increased supply from gas plants would offset lower refinery production due to reduced crude oil runs.
- Jones Act waivers may be required to allow movement of Gulf Coast supplies to meet East Coast demand.
- Expedite allocation of LIHEAP funds to assist those unable to make home heating payments.
- Assist in expediting rail car use during crisis (Department of Transportation and American Association of Railroads).
- Relax standards regarding truck hours of service, routing, and weight restrictions (Department of Transportation).
- The U.S. government should avoid restricting exports—Canada and Mexico are major supply sources and may retaliate if exports from the U.S. are curtailed.

CONCLUSION—In a major supply disruption (caused by extremely cold weather), government actions may be necessary to ensure adequate distribution.

POTENTIAL GOVERNMENT RESPONSES TO SYSTEM DISRUPTIONS

OVERVIEW—Neither federal nor state governments should institute mandates which reduce system flexibility such as allocation and price controls. Recommended temporary federal government responses to severe short-term supply disruptions should include the following:

CRUDE OIL LOSS—If crude oil is disrupted, it is important that Strategic Petroleum Reserve (SPR) crude oil be made available quickly to shorten the period between loss of imported oil and full rate delivery from the SPR.

- The Strategic Petroleum Reserve provides valuable insurance against a major supply disruption and the NPC recommends early and appropriate release of SPR oil in emergency situations.
- Rapid response waivers to Jones Act cabotage requirements to enable available foreign-flag tanker capacity to be utilized for coastwise movements of SPR crude oils, finished products, and the like.
- Pre-emption of various states' unlimited liability statutes pertaining to oil spills in order to conform to limits as established by the International Maritime Organization of the United Nations and to maximize tanker capacity availabilities.

POTENTIAL GOVERNMENT RESPONSES TO SYSTEM DISRUPTIONS

PRODUCT LOSS—If product supply is disrupted, the relaxation of stringent Reid Vapor Pressure (RVP) regulations on motor gasoline could add 2% additional gasoline production for each one (psi) RVP waiver.

- The RVP legislation represents a spreading movement among individual states to reduce ozone pollution by setting stricter volatility standards than those imposed by the U.S. Environmental Protection Agency (EPA). State-by-state specification changes can cause market segmentation which reduces the flexibility of existing distribution logistics.
- In general, the EPA requires that the lower RVP specs be met at terminals by May 1 and at retail outlets by June 1. In order to meet these requirements refiners begin to blend down in early March. Consequently, a comfortable level of motor gasoline inventories on March 1 does not ensure that the system will avoid stress. If a disruption occurs during the driving season, a significant portion of the inventories is likely to be of a higher RVP specification than the EPA permits. To avoid shortage situations, it may be necessary for the EPA to temporarily waive individual states' RVP requirements until the crisis is resolved.
- Depending on the severity and duration of the disruption, consideration should be given for the relaxation of sulfur specifications for distillate and fuel oil.
- Expedite the allocation of LIHEAP funds to assist those unable to make home heating payments.
- Relax certain Department of Transportation standards regarding truck hours of service, routing, and weight restrictions. This is a particular issue with the transportation and distribution of propane.
- Pre-emption of various states' statutes pertaining to price and allocation controls, including restrictive product set-aside programs—all of which impede the orderly functioning of the distribution mechanisms.

WORLD FLEET (Million Deadweight Tons)				
VESSEL SIZE MDWT	NO. OF VESSELS	TOTAL	ACTIVE	IDLE
10-25	490	8.8	8.6	0.2
25-45	730	24.7	24	0.7
45-80	367	22.3	21.9	0.4
80-150	579	60.5	58.2	2.3
150-300	395	95.0	86.9	8.1
300+	84	31.2	25.6	5.6
	2645	242.3	225.0	17.3 (7% idle)
<p>* Totals may not equal the sum of components due to independent rounding.</p> <p>Source: Extracted from Lloyd's Shipping Index 3/90.</p> <p>About 60% of the idle % shown above is available on short notice. The remainder is under repair, damaged or storing oil.</p>				
U.S. FLEET - JONES ACT (Thousand Deadweight Tons)				
VESSEL SIZE MDWT	NO OF VESSELS	TOTAL	ACTIVE	IDLE
10-25	7	65	63	2
25-45	71	2430	2352	78
45-80	27	1641	1592	49
80-160	20	2094	2094	0
160-300	17	3416	2967	449
300+	0	0	0	0
	142	9646	9068	578 (6% idle)
<p>Source: Marad 8/1/90 - updated to 12/90 per industry knowledge</p> <p>All the idle % shown above is available on short notice.</p>				

POTENTIAL GOVERNMENT RESPONSES TO SYSTEM DISRUPTIONS

U.S. FLAG TONNAGE ISSUE

U.S. FLAG TANKER FLEET SUMMARY

U.S. Flag Jones Act Tankers

Total Number of Jones Act Tankers - 142 (As of August 1, 1990)
 Average age of all Jones Act Tankers - 17.02 years
 Average age of Jones Act Tankers under 54,000 DWT - 18 years
 Average age of Jones Act Tankers over 54,000 DWT - 15 years

U.S. Flag Vessels Under Construction

Total number of Tankers under construction - 0
 Above list only includes U.S. Flag vessels
 with DWT in excess of 16,692.

Source: Dietze Inc., Maritime Administration

POTENTIAL GOVERNMENT RESPONSES TO SYSTEM DISRUPTIONS

U.S.-FLAG TONNAGE ISSUE

JONES ACT CABOTAGE REQUIREMENTS—Feasibility of obtaining variances to remove restrictions and increase flexibility concerning the use of foreign-flag tankers to transport product between domestic ports.

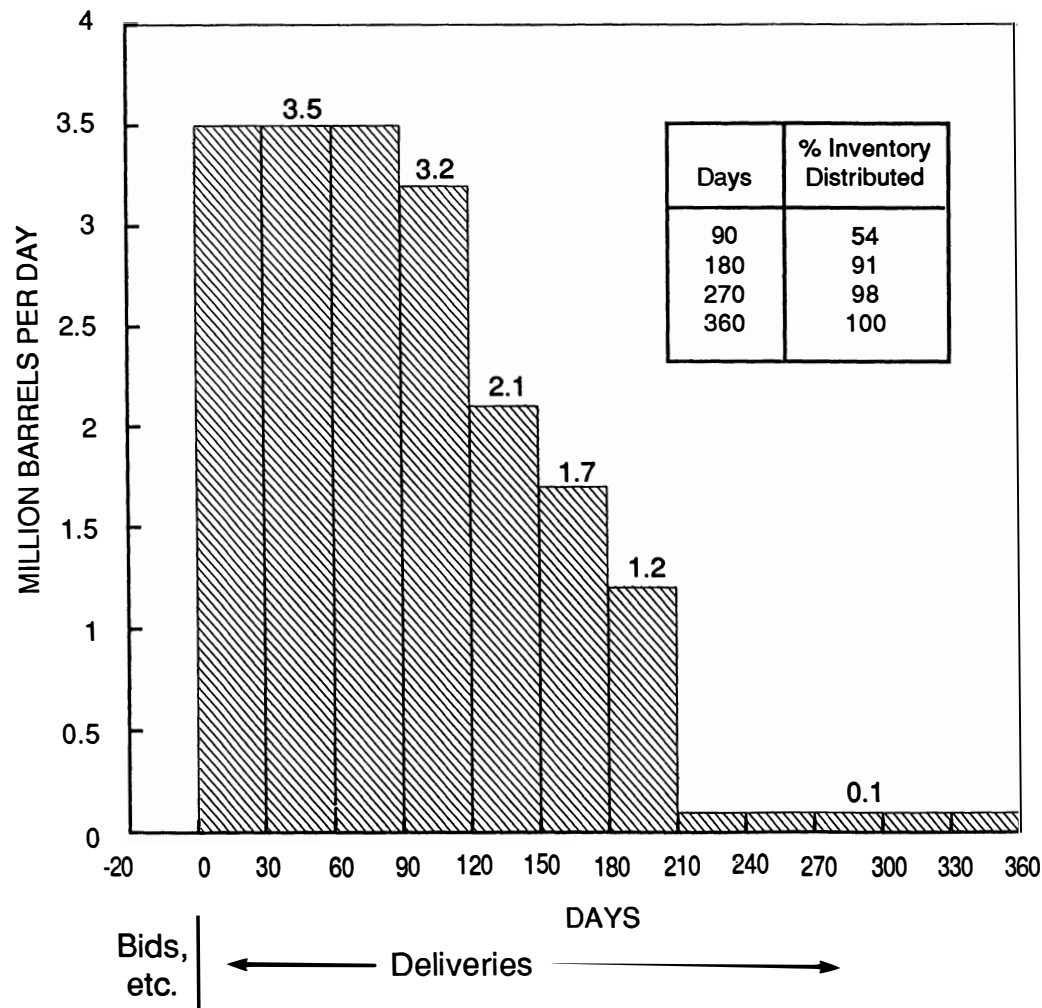
- All trade among U.S. ports requires U.S.-flag vessels. By tonnage, most of the U.S.-flag oil carriers move Alaskan North Slope (ANS) crude oil. However, about 50% of the ships are in clean product service. The U.S. spot shipping rates have been increasing over the last several years, reflecting the growing tightness. This general trend does not properly highlight the real tightness of the market in the winter when demand peaks (due to higher heating fuel oil demands). In the winter, the loss of one U.S.-flag tanker can cause dramatic supply imbalances.
- Only 6% of the U.S.-flag tankers are idle. This is just 5 vessels or about 500 thousand deadweight tons. Two of these idle vessels (making up over 80% of the idle tonnage) are VLCC tankers that move crude oil from Alaska to Panama and are too large for other U.S. ports (except LOOP). This compares to a 7% idle foreign fleet, which is an estimated 100 tankers or about 17 million deadweight tons.
- A disruption of crude oil supply may require an increase in shipments from Alaska to the Gulf Coast. The 2 idle U.S. VLCC tankers could only move an additional 100 thousand barrels per day (estimated) of crude oil from Valdez to the Gulf Coast. Distortions could be avoided if Jones Act cabotage waivers are issued.
- Delivery of SPR crude oil would impose additional marine tonnage requirements. The 3 idle tankers available that can fit into most U.S. ports could move only an additional 100-200 thousand barrels per day (estimated) of oil. It is estimated that maximum requirements are expected to exceed surplus U.S.-flag capacity. Consequently, a blanket Jones Act cabotage waiver would be necessary to allow foreign-flag tankers to trade between U.S. ports.
- Foreign-flag tanker tonnage is currently available and interruptions of U.S. imports would make the surplus even larger.

CONCLUSION—*The U.S. Maritime Administration has a memorandum of understanding in place and will be prepared to move quickly (within 48 hours) to grant Jones Act cabotage waivers on a case-by-case basis. This memorandum is a step in the right direction. However, any action which would serve to reduce implementation time to less than 48 hours and consideration of a blanket waiver during an SPR draw would be seen as an even more desirable solution.*

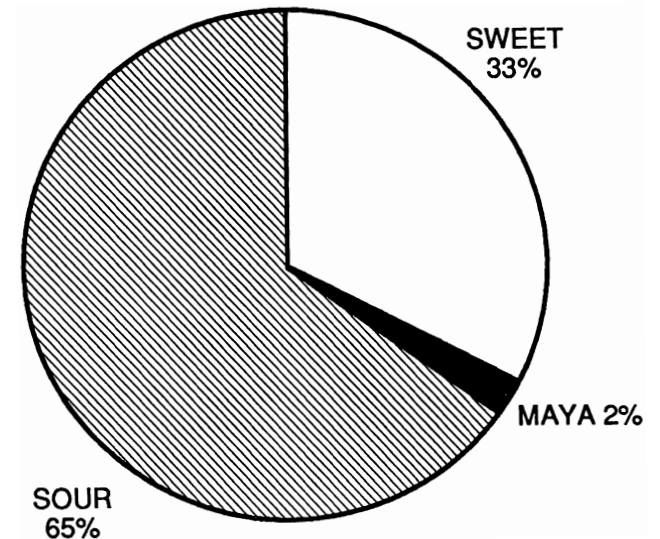
THE STRATEGIC PETROLEUM RESERVE

THE ONLY INCREMENTAL SUPPLY

DRAWDOWN CAPABILITY



QUALITY



33.7° API AVERAGE
1.11% SULFUR AVERAGE

SOURCE: U.S. Department of Energy.

THE STRATEGIC PETROLEUM RESERVE THE ONLY INCREMENTAL SUPPLY

OVERVIEW—Essentially all crude oil productive capacity is fully utilized. The Strategic Petroleum Reserves (SPRs) in this country and abroad are presently the only source of incremental supply in the event of a crude oil disruption.

DRAWDOWN—As shown on the left above, U.S. SPR stocks, about 590 million barrels, can be drawn down at a maximum rate of 3.5 million barrels per day for 90 days. The maximum rate then drops in steps over the next four months. After 7 months' drawdown at maximums, the rate drops to 100 thousand barrels per day.

- Governments with strategic stocks cannot wait to see a physical "shortage" before making and announcing the decision to draw their stocks. As demonstrated since the embargo of Iraq and Kuwait, the oil market, like other free markets, will rebalance supply and demand with higher prices.
- The government is urged to make and announce its decision to use the SPR stocks as soon as feasible after a disrupting event. The perception of early decisive action and the assurance of a continuing supply line will have a calming effect on the market.
- The plan for the draw should include the largest possible volume. There is little risk that SPR supplies, drawn too soon, will glut the market: companies will not bid for supplies they do not need. Hence, the drawdown might be smaller than anticipated, but will be enough to satisfy market demand.
- A drawdown of SPR stocks in the United States should be accompanied by drawdowns of strategic stocks in other nations as well.

WAIVERS—A blanket waiver of the cabotage provisions of the Jones Act will be necessary in order to ensure the smooth delivery of SPR crude oil to East Coast refineries. Since imports account for more than 90% of the crude oil refined on the East Coast, the region is likely to be hard hit by a supply disruption and Jones Act restrictions will slow the rebalancing process. The Gulf Coast and Midwest refineries will receive SPR supplies via pipeline, and the West Coast is a net supplier of domestic crude oil to other regions.

QUALITY—The quality of the SPR crude oil is similar to the average run in U.S. refineries—slightly lighter, about the same sulfur content. As shown in the chart on the right above, the sweet crude oil accounts for about one-third of total SPR volumes. Among the sweet crude oils that meet the SPR's specifications are Bonny Light, Brass River, Brent, Ekofisk, Escravos, Forties, Kole Marine, Ninian, Saharan Blend, Statfjord, West Texas Intermediate, and Zarzaitine. Sour crude oil other than Maya accounts for 65% of the SPR volumes. These crude oils might include Arabian Berri, Arabian Light, Dubai (Fateh), Flotta, Isthmus, Lagomedio, Oman, Qatar Marine, Tia Juana Light, Upper Zakum, and West Texas Sour. Maya, Mexico's heavy crude oil, accounts for only 2% (11 million barrels) of the SPR's volume. Hence, although Mexico has supplied 44% of all the stocks in the SPR, 95% of the Mexican supplies are its higher quality crude oils.

CONCLUSION—*The Strategic Petroleum Reserves in the U.S. and abroad are presently the only incremental crude oil supplies available to world markets. In the event of a supply disruption, the early and appropriate use of the SPRs would tend to calm petroleum markets.*

PART II

REVIEW OF THE EIA SHORT-TERM ENERGY OUTLOOK PROCESS AND MODELS

REVIEW OF THE EIA SHORT-TERM ENERGY OUTLOOK PROCESS AND MODELS

DATA BASES AND DATA FLOW

The Energy Information Administration (EIA) developed the Short-Term Integrated Forecasting System (STIFS) to generate short-term (up to eight quarters) forecasts of U.S. supplies, demands, imports, exports, and stocks of various forms of energy. The STIFS produces these results at the monthly level, which are then presented in a quarterly format for publication as the EIA's *Short-Term Energy Outlook* (STEO). Inputs to the STIFS consist of historical data and forecasts that relate to production, demand, imports, exports, and stocks of both primary and end-use energy sources. Historical data come mainly from data bases that support a number of EIA publications; among them are the *Petroleum Supply*, the *Petroleum Marketing*, the *Electric Power*, and the *Natural Gas Monthlies*.

Forecasts of end-use energy demands, primary energy production, refinery inputs and outputs, net imports, and stocks are generated by one or more of the following methods:

- Econometric forecasting techniques
- Time-series forecasting techniques
- Data analysis/judgment by EIA analysts
- Market-clearing assumptions.

Within the STIFS, a variety of energy-market conditions that affect projections of energy supplies and demands can be simulated. Considerable analyst intervention may be required to obtain meaningful results in instances where input assumptions stretch the range of the individual equations' historical data bases.

Figure 1 is a simplified portrayal of the data flow within the STIFS that results in a STEO. The current version of the STIFS consists of a price model, a demand model, and a supply and integration (or balancing) model. Each of these three primary models is fed data from other models, data bases, analyst assumptions, and other inputs external to the STIFS environment. Reasonableness checks are made frequently by EIA analysts during the process of producing a STEO. Reviews are held with other groups, divisions, branches, etc. within the EIA, and consultants and industry contacts are asked to comment. The STEO report is prepared by the EIA's Office of Energy Markets and End Use, Energy Analysis and Forecasting Division. The *Short-Term Integrated Forecasting System, 1990 Model Documentation Report* (DOE/EIA-M041) is available from the Department of Energy's National Energy Information Center or the NPC. The version of the STIFS formally documented was used by the EIA to create the first quarter 1990 STEO. Documentation of the current version of the various STIFS equations, the variables used, and statistical analyses of the regressions is not available. However, EIA personnel provided insight

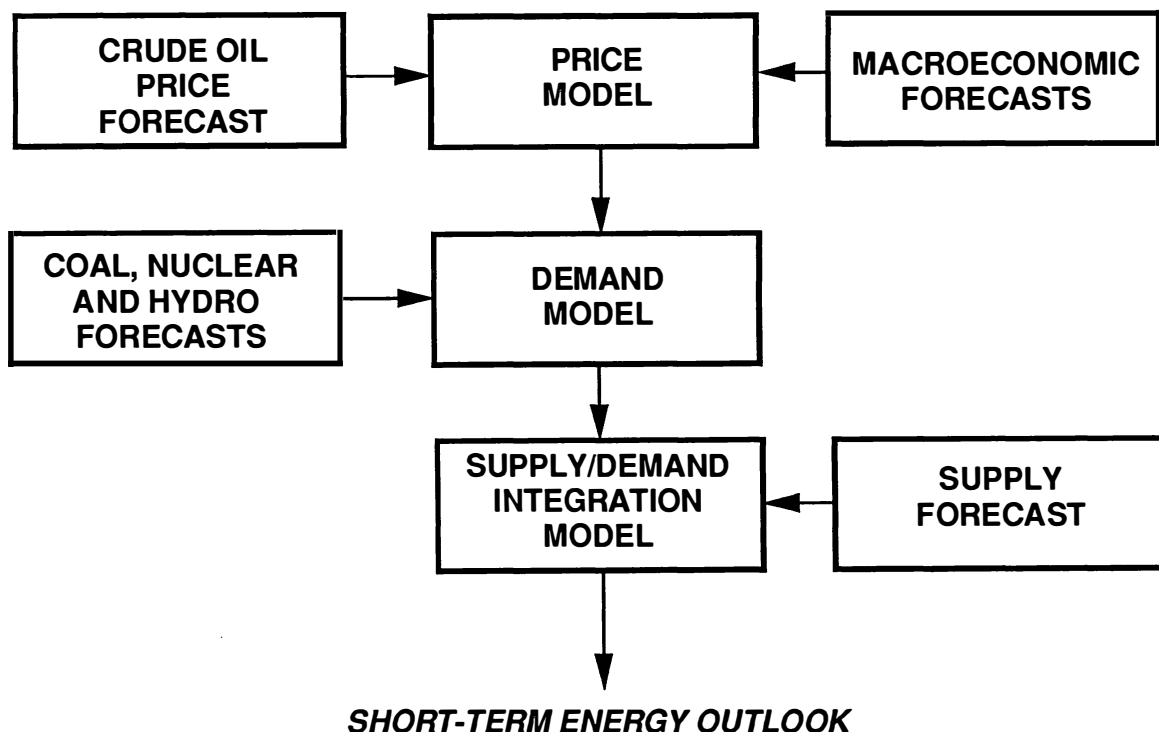


Figure 1. EIA Short-Term Integrated Forecasting System (STIFS).

into the revisions to the published methodology. All comments pertaining to the NPC review of the STIFS refer to this informally updated version.

MACROECONOMIC FORECAST

The basic macroeconomic assumptions needed to produce the energy demand and supply forecasts are derived from a simulation of a DRI/McGraw-Hill quarterly model of the U.S. economy. The DRI model can be solved using assumptions about world oil prices, other basic energy prices, and economic trends different from the published DRI control forecasts. The EIA staff make adjustments to a particular DRI control forecast to produce a set of consistent macroeconomic variables that include the desired world crude oil price profile and the petroleum and other energy product prices generated by the pricing models of the STIFS. Model adjustments reflect the EIA's current view of general economic growth in the United States; in particular, Gross National Product, Disposable Personal Income, and the Industrial Production Index.

The DRI/McGraw-Hill division of Standard and Poor's Corporation markets a forecast of the U.S. economy. This widely used forecast can be purchased either as a hard-copy DRI control case or as a PC computer model. When the model itself is acquired, changes can be made to a wide selection of parameters, resulting in a forecast tailored to the user's particular notion of future trends. As noted, the EIA takes this latter approach in developing the macroeconomic variables needed by the STIFS.

The DRI model claims to incorporate the best insights of many theoretical approaches to the business cycle. In addition, the DRI model includes the major properties of long-term growth models. This structure is meant to guarantee that robust long-run properties will temper short-run cyclical developments. The DRI model captures the full simultaneity of the U.S. economy, forecasting 1,200 concepts spanning final demands, aggregate supply, prices, incomes, international trade, industrial detail, interest rates, and financial flows. The model structure includes eight interactive sectors: domestic spending, domestic income, tax policy, international transactions, financial considerations, inflation and productivity, simulated supply potential, and market expectations.

The domestic spending, income, and tax policy sectors model the central circular flow of behavior as measured by national income and product accounts. Consumer spending is divided into durable goods, nondurable goods, and service categories. Business spending includes fixed investment categories and inventory spending categories. The housing sector of the DRI model explains new construction as a decision primarily based on the after-tax cost of homeownership relative to disposable income. Government spending is largely exogenous at the federal level and endogenous at the state and local levels.

The industrial production sector includes 60 standard industrial classifications. Production is a function of various cyclical and trend variables. Domestic spending, adjusted for trade flows, defines the economy's value-added or gross national product. The distribution of income among households, business, and government is determined in the model. The model tracks personal, corporate, payroll, and excise taxes separately. Users may set federal tax rates; tax revenues are then simultaneously forecast as the product of the rate and the associated pre-tax income components. The international sector is a block that can either add or divert strength from the flow of domestic income and spending.

The use of a detailed financial sector and of interest rate and wealth effects in the spending equations recognizes the importance of credit conditions on the business cycle and on the long-run growth prospects for the economy. Inflation is modeled as a controlled, interactive process involving wages, prices, and market conditions. Full employment or potential national output is estimated within a production function framework. Total productivity of labor, capital, and energy is driven by research spending and trends to reflect technological progress. Taxation influences labor supply and all investment decisions. The principal nuance relating to expectations in the DRI model is an endogenous volatility factor influencing interest rates.

The Macroeconomic Group of the Energy Analysis and Forecasting Division maintains the EIA copy of the DRI model. After specific EIA assumptions are overlaid on the DRI model, a simulation is run on the PC. Following a review of the results, the variables needed by the STIFS are uploaded to the mainframe environment of the STIFS.

U.S. ENERGY DEMAND AND PRICE MODELS

Motor Gasoline

The demand for motor gasoline is estimated econometrically with two equations linked by the identity:

$$\text{Gasoline Demand} \equiv \frac{\text{Total gasoline vehicle miles traveled}}{\text{Average gasoline vehicle miles per gallon}}$$

Statistics for total gasoline vehicle miles and gasoline vehicle miles per gallon are not measured on a monthly basis. Therefore, total vehicle miles traveled and total vehicle miles per gallon, calculated as total vehicle miles traveled divided by total gasoline demand, are used as proxies. Data are seasonally adjusted.

A generalized least squares methodology is used to estimate total vehicle miles traveled as a linear function of the real cost per mile of gasoline over the previous twelve months (retail price of gasoline adjusted by the Consumer Price Index, divided by total vehicle miles per gallon) and real disposable income. Total vehicle miles per gallon is estimated as a logarithmic function of time and a measure of real retail price of gasoline, again using a generalized least squares model.

The gasoline demand forecasts have experienced an average absolute error of 1.3 percent or 90 thousand barrels per day (MB/D) over six quarterly outlooks from January 1988 through April 1989, as reported in the 1989 Annual Supplement to the STEO. Approximately 60 MB/D of the underestimation was attributed to an overly conservative view of the economy and disposable income in particular. Factors affecting the vehicle miles per gallon, such as reinstitution of a 65 mph speed limit on many of the states' interstate highways, were also unaccounted for. More recent editions of the *Short-Term Energy Outlook* have reduced the absolute error to about 1 percent.

The retail price of gasoline is modeled as a function of the previous month's retail price adjusted by the consumer price index, and the previous month's wholesale price of gasoline. The wholesale price is estimated as a function of the previous month's wholesale price and the previous month's refiners' acquisition cost of crude oil, which is an exogenous variable and is seasonally adjusted.

The gasoline price forecasts have historically experienced a larger absolute error, averaging 6.2 percent or 6.6 cents per gallon for the six quarterly outlooks from January 1988 through April 1989 with quarters as high as 20 cents per gallon. This has generally been a result of unanticipated crude oil price changes and a tendency to underestimate refiner and retail margins during the period.

Overall the gasoline demand and price models provide statistically significant results while allowing sufficient flexibility to account for disparities through analyst intervention, which is likely to be required any time there is a sustained significant deviation from the defined trends of the independent variables.

Jet Fuel

The demand for kerosene jet fuel is modeled econometrically with two equations that are linked together by the identity:

$$\begin{array}{lcl} \text{Kerosene} & & \\ \text{jet fuel} & \equiv & \frac{\text{Industry revenue ton-miles} / \text{aircraft load factor}}{\text{Average aircraft efficiency}} \\ \text{demand} & & \end{array}$$

Aircraft efficiency is defined as available ton-miles divided by total jet fuel demand (essentially constant for the short term). Aircraft load factor is a measure of the utilization defined as industry revenue ton-miles divided by the available ton-miles.

Industry revenue ton-miles is modeled as a logarithmic function of industry average airline revenue yield over the previous twelve months adjusted by the consumer price index, and real disposable income. Average airline revenue is modeled as a seasonally adjusted function of time, the purchase price of tickets, and real disposable income.

Total jet fuel demand is then derived by adding the demand for military jet fuel (an exogenous variable) to the predicted kerosene jet fuel demand. The model parameters of this depiction appear reasonable.

Distillate Fuel Oil

Distillate fuel oil demand consists of two categories, utility and non-utility uses. Distillates for utility use (electricity generation) are derived from electricity demand and an energy balance on fuels to produce electricity. Utility usage will be discussed under electricity generation.

Non-utility distillate demand is modeled by three separate equations, one each for transportation, residential/commercial, and industrial/other sectors.

Transportation distillate demand is modeled as a linear function of real diesel fuel price and industrial production. Data are seasonally adjusted before regression. Both variables are statistically significant, with manufacturing output having the stronger effect. The price term has the correct mathematical sign, i.e., higher prices result in lower demands. Statistically, the model is strong.

Residential and commercial distillate demand is modeled as a linear function of population-weighted degree-days in the Northeast (where distillates are a major heating fuel) and seasonal factors. Both degree-days and seasonal variables are statistically significant, and the model is strong.

Distillate for industrial and miscellaneous uses is modeled as a linear function of the industrial production index, the relative price of distillates and natural gas to industrial users, heating degree-days, and seasonal variables. The relative price of distillates to natural gas would be an appropriate variable if there is enough natural gas available to handle peak demands and dual fuel capability exists. Natural gas availability will be further discussed in the section on the modeling process. The winter seasonal variables tend to be the strongest variables statistically. Higher distillate price relative to gas price results in lower demand, as would be expected. Statistically, the model is good, but concern relating to the ultimate potential of natural gas for oil substitution exists.

Residual Fuel Oil

Residual fuel oil is grouped into two categories, utility and non-utility uses. Residual fuel oil for utility uses (electricity generation) is derived from electricity demand and an energy balance on fuels to produce electricity. Utility usage will be discussed under electricity generation.

Non-utility residual fuel is modeled as a seasonally adjusted linear function of the index of industrial production, the real price of residual fuel, heating degree-days, and several variables to exclude the effect of non-typical periods. Surprisingly, the relative price of residual fuel to natural gas is not a variable. Perhaps this variable can be tested when the model is updated. Industrial production is a logical variable because fuel for bunkering and residual fuel for industrial use are both tied to industrial activity. Degree-days has the strongest effect of the major variables. Statistically, the model is adequate. Presumably, residual fuel oil price is a proxy for the relative price of residual fuel oil to natural gas. The lack of constraint on maximum gas use is a concern.

Other Petroleum Products

The other petroleum products category consists of four models, one each for liquefied petroleum gases (LPG), ethane, petrochemical feedstocks, and miscellaneous products. LPG, ethane, and petrochemical feedstocks are all tied closely to the index of chemical production. Statistically, these three models are not very strong, but this could be expected due to the highly volatile nature of chemical production relative to changes in the economy.

LPG is modeled as a linear function of the index of chemical production, the wholesale price of heating oil relative to natural gas to electric utilities, and heating degree-days. Data are seasonally adjusted before regression. Chemical production has the strongest statistical effect.

Ethane is modeled as a logarithmic function of the chemical production index, the real price of heating oil relative to natural gas, and several time-related variables. The time-related variables are statistically the strongest.

The petroleum feedstock model is similar to the ethane model, as could be expected, because both measure primary feedstocks to basic organic chemical facilities. A strong variable is the relative price of heating oil to natural gas. As liquids become more expensive relative to natural gas, there is a growing incentive to recover ethane from natural gas for olefins unit feed.

Miscellaneous products is a broad category, consisting of nine products that, while important in total volume, do not justify modeling separately. The group includes aviation gasoline, kerosene, special naphthas, lubricants, waxes, petroleum coke, asphalt and road oil, refinery gas, and a number of other small-volume products. Variables include the industrial production index and several time-related variables. The model is linear and data are not seasonally adjusted. Summer months have very strong statistical significance probably due, in part, to asphalt and road oil demands during warmer months. The only other product having a strong seasonal demand is kerosene, which peaks during winter months. This model is one of the strongest statistically, which is quite surprising, considering the diverse nature of the products. These results indicate that modeling the nine products separately would result in little forecasting improvement.

Electricity, Natural Gas, and Coal Demands

To complete the energy demand forecast, the model includes separate representations of electricity demand, natural gas demand, and coal demand. In general, these models are driven by weather and economic conditions, and, to a lesser extent, energy prices. Additional variables attempt to capture historical trends in energy efficiencies and technological changes. By modeling historical trends, the resulting forecasts assume that these trends will continue. This assumption ignores short-term deviations in the economy such as spending mix (energy intensive sectors versus non-energy intensive sectors), technological advances, government regulations, and large swings in energy prices. Each model is discussed below. On balance, these econometric models represent reasonable simulations of energy demands.

Electricity

Demand for electricity is the sum of four different models that represent the following sectors: residential, commercial, industrial, and other. The models for residential and commercial demands are driven primarily by weather variations (degree-days) with a smaller influence from economic conditions (GNP). The model for industrial demand is appropri-

ately driven by industrial production. All models are based on data accumulated over the last ten years and, as such, they have captured historical trends in energy efficiencies and fuel switching or substitution. The models reflect no direct price elasticity and ignore energy conservation measures, except those inherent in the historical trends. These models have demonstrated reasonable correlation and are generally accepted methods for short-term forecasting.

Natural Gas

Natural gas demand is the sum of five different models that represent the following sectors: residential, commercial, industrial, utility, and other. The models for residential and commercial gas demands are driven by weather variations (degree-days) and changes in customer population.

The model for industrial gas demand is driven by industrial activity for key gas consuming industries, and is influenced by seasonal patterns and energy prices of competing fuels—gas and fuel oil. Fuel substitution is assumed to be directly related to energy prices, but no supply or saturation limits appear to be directly reflected to restrict the extent of fuel substitution. In addition, environmentally driven fuel substitution is not represented by the model. The utility gas demand is dependent on total electricity demand. The portion generated from gas is modeled as a function of the relative prices of the oil to gas. Other natural gas demand is driven by industrial natural gas demand and gas price.

Coal

Coal demand is the sum of four different models that represent the following sectors: electric utility, coke plants, general industry, and residential/commercial. The electric utility sector is, by far, the largest consumer of coal and, as such, the model is driven by electricity generation requirements, coal-fired generating capacity, and seasonal factors.

Coal demand for coke plants is driven by raw steel production, which is a function of domestic investment and exchange rate. Coal demand for general industry is driven by industrial production. Residential and commercial coal demand is driven by weather variations (degree-days).

The parameters used to model the demands for coal appear to be reasonable.

U.S. ENERGY SUPPLY MODEL

Crude Oil Production

U.S. crude oil production is estimated by the EIA's Office of Oil and Gas in Dallas, Texas, as the sum of output in Alaska and the Lower-48 states.

Alaska

Alaskan crude oil production is derived by summing individual monthly forecasts for South Alaska and the North Slope. South Alaska oil production is extrapolated using the most recent historical trends. The remainder of Alaskan production is based on annual estimates from the operators of other Alaskan fields. The EIA adjusts these production rates using forecast crude oil prices.

Lower-48 States

Crude oil production in the Lower-48 states is based on oil prices, the decline rate of old oil, output from marginal wells, and new oil added by drilling.

Total wells drilled is dependent on drilling expenditures, the rotary rig count, drilling efficiency, drilling permits, and the number of active seismic crews. The number of oil wells drilled is based on the historical ratio of oil wells to total wells drilled. The decline rate in old oil is computed from historical trends.

The contribution from marginal wells is based on operating cost data relative to the oil price.

The latest EIA Annual Supplement to its *Short-Term Energy Outlook* compares EIA's previous forecast with actual data from January 1988 to April 1989. For U.S. crude oil production, the average absolute error by quarter is only 2.1 percent, which is commendable.

The fourth quarter 1990 STEO included a projection of U.S. crude oil production based on \$25, \$30, and \$35 per barrel world crude oil price levels for 1991. The absolute difference in U.S. production between the \$25 and \$35 cases was 510 MB/D by year-end 1991. Extended discussions with EIA staff pointed out that a number of non-economic adjustments were made between price cases.

Electricity, Natural Gas, and Coal Supplies

Electricity generation, natural gas supply, and coal production are each modeled separately.

Electricity

Electricity demand is met through non-utility purchases, net imports from Canada, and power generation with an allowance for transmission and distribution losses. Non-utility purchases and net imports are assumed from recent history and knowledge of firm contracts.

Electricity generation is modeled for each production mode: coal, nuclear, hydroelectric, petroleum, geothermal, and other. Coal and nuclear power generation rates are based on forecast plant capacities using

historical utilization rates. The model for hydroelectric power generation assumes normal precipitation and is adjusted for seasonality.

Nuclear, hydroelectric, geothermal, and other generating rates are assumed to be independent of electricity demands, while coal and oil/gas power generation is by difference. A change in electricity demand results in a change in both coal and oil/gas power generation. The split between power generated from fuel oil and from natural gas is determined by their relative prices. This is of concern because of the limited oil-to-gas substitution potential. Further, the split between distillate and residual fuel oil is a fixed ratio and is of concern.

However, the base power generation models appear to be fairly realistic, but the methodology related to the division between fuel oil and natural gas is somewhat less certain.

Natural Gas

The supply of natural gas is assumed to be demand limited. Domestic gas production is the balance between total natural gas demand, net imports, and inventory changes. The supply model does not appear to reflect the impact of unusual weather conditions. Analyst intervention is necessary to constrain the model output within perceived boundaries.

Coal

Domestic coal supply is assumed to be unlimited. Coal production is the balance of coal demand and net exports. Analyst intervention is necessary to constrain the model output within perceived boundaries.

INTERNATIONAL SUPPLY AND DEMAND

The world petroleum balance is prepared by the EIA International and Contingency Information Division (ICID) exogenous to the STIFS for inclusion in a STEO. No international petroleum supply and demand model similar to the STIFS is available for preparing short-term forecasts. The ICID maintains a model for long-range international forecasts (Oil Market Simulation Model, or OMS) and a model to simulate the world oil market during a disruption of oil supplies (Disruption Impact Simulator, or DIS). For short-range forecasts, the ICID has developed a methodology that uses outside contractors, industry contacts, international agencies, and other diverse data sources. The steps in this methodology are not officially documented and are summarized here based on an interview the NPC conducted with the ICID Director.

In the conduct of its routine responsibilities, the ICID maintains a "base case" of the current world petroleum situation, best characterized as a business-as-usual assessment. When the ICID is called upon to provide an

international petroleum short-range outlook, the current base case forms the starting point for the reference case STEO. The following steps comprise the methodology used in preparing the STEO projection:

- Supply

- U.S. supply is taken directly from the STIFS process. The international outlook follows the same iterative STIFS process, providing necessary feedback.
- OPEC production is based on published quotas, trade press reports of lifting rates, industry contacts, and ICID analyst judgment.
- Other non-OPEC supplies are derived from three sources: an extensive ICID data base of reserve and reserve/production ratios for all producing countries, forecast of production or production capacity by independent sources, and the trade press for announcements of new discoveries and production facilities maintenance schedules.
- Centrally Planned Economies net exports are calculated using oil production and consumption forecasts from two different outside contractors, one specializing in China and the Far East and one specializing in Eastern Europe and the Soviet Union, as well as information obtained from the trade press and outside sources.

- Demand

- U.S. demand is taken directly from the STIFS; as with U.S. supply, this is an iterative process as the STIFS process proceeds.
- U.S. territories demand is taken from recent historical trends.
- Organization of Economic Cooperation and Development (OECD) country demand is based on recent trends for major countries, adjusted using projections of economic growth from an outside contractor. Industry contacts and trade reports are used to make second order adjustments.
- Less Developed Countries (LDC) demand is based on historical trends, industry contacts, and trade reports.
- Historically, a difference (statistical discrepancy) exists between the international balance of supply, demand, and stocks. The current level of non-U.S. discrepancy being used is 0.2 million barrels per day.

- Stocks
 - The change in stock levels is the net of supply, demand, and statistical discrepancy.
 - A reasonableness check is made using historical ranges.

For alternate price STEO cases, the steps are as follows:

- Supply
 - U.S. supply is taken from the STIFS.
 - OPEC production is calculated based on maintaining commercial oil inventories of the OECD countries at assumed levels of forward consumption.
 - All other supply is assumed not to change with short-range changes in world oil price.
- Demand
 - U.S. demand is taken from the STIFS.
 - Non-U.S. demand is based either on a DIS model run or an assumption of -0.1 percent elasticity.

Outside consultants and industry contacts are asked to comment on the credibility of results for the alternate price STEO cases.

This entire methodology potentially could be replaced with a series of DIS model runs. The DIS model, however, was developed to forecast world crude oil prices as output, not input. The DIS model has not been tested in this way and it is not clear if the resulting iterative procedure would be an improvement over the current methodology.

INTEGRATION AND RECONCILIATION

The steps taken to produce a STEO involve numerous reviews, interactions, model feedback, and iterations over an extended period of time. Table 2 is an example of the schedule the EIA follows in producing a STEO (the schedule shown is for completion of the first quarter 1991 STEO). Typically, it takes about two months from the start of the quarterly STIFS process to final approval. Another few weeks are needed for publication and distribution. If necessary, this time schedule can be reduced to a few days with reasonable results, as was demonstrated during the NPC Price Test Case. About 30 to 40 individuals are involved either full- or part-time

Table 2
FIRST QUARTER 1991 STEO SCHEDULE

EVENT	DATE
Preliminary Macro Forecast	11-13-90
Office of Energy Markets and End Use (EMEU) Editorial Meeting	11-15-90
World Oil Price Forecast	11-30-90
Hydro, Nuclear, and Electricity Imports and Non-Utility Forecasts	12-05-90
Demand Model and Graphics Changes	12-05-90
Preliminary Wellhead Gas Prices	12-05-90
Final Macro Forecast	12-10-90
Preliminary Demand Forecasts	12-12-90
Preliminary Electricity and Coal Forecasts to Office of Coal, Nuclear, Electric and Alternate Fuels (CNEAF)	12-14-90
Dallas Field Office Oil Forecast	12-14-90
Final Wellhead Gas Prices	12-17-90
Electricity and Coal Meeting	12-18-90
Preliminary Oil and Gas Forecasts to Office of Oil and Gas	12-19-90
Oil and Gas Meeting	12-21-90
Coal Production Forecast	12-21-90
First Graphics Data Update	12-27-90 12-28-90

Table 2 (Continued)

EVENT	DATE
International Forecast	12-28-90
Draft Text	12-28-90
Integrated Forecast	12-31-90
Second Graphics Data Update	1-02-91 1-03-91
Administrator Review of Preliminary Forecasts and Special Topics	1-04-91
Archive of Price and Demand Files	1-08-91
Petroleum Sensitivity Forecasts	1-09-91
Final Tables and Graphs	1-11-91
Historical Data Frozen	1-11-91
Final Text to Director of EMEU	1-10-91 1-15-91
Office Directors' Review	1-18-91 1-24-91
Coal Forecast to Coal Data Division	1-28-91
Office Review Response to Division Director	1-29-91
Press Release	1-18-91 1-29-91
CNEAF Review Meeting	1-30-91
Administrator Approval	1-31-91 2-06-91
Print and Mail	2-11-91 2-15-91

during this two-month period. Each of the steps in the STIFS process can involve initial, several intermediate, and final model runs. The EIA staff do not routinely document the types of changes or magnitude of the resulting modifications made at each step. At the request of the NPC, the EIA developed a case similar to the quarterly STEO using petroleum situation variables that stretched the limits of the historical ranges of previous STEOs. As a part of this test case, the NPC asked the EIA to document the intermediate changes made so that an assessment of the interaction between analyst intervention and model capability could be determined. This assessment is included in the section entitled "Model Capabilities—NPC Price Test Case."

Integration and reconciliation of STIFS results and exogenous inputs are managed in the Short-Term Integrating Model (STIM), which reconciles supply with demand, in physical units (barrels, tons, cubic feet, or kilowatt hours), for total petroleum products (motor gasoline, distillate fuel oil, residual fuel oil, jet fuel, LPG, and other products), natural gas, coal, and electricity. It converts the physical units to energy and compares and aggregates fuels that were previously in diverse physical units.

A mathematical representation of the U.S. energy network is contained within the integrating model. This network structure comprises four energy subnetworks: electric utility, natural gas, oil and refining, and coal. Domestic supplies of end-use energy sources are derived based on the expected levels of domestic primary energy production and domestic energy end-use consumption. Initial estimates for production, net imports, and stock changes of primary energy sources are aggregated to determine final end-use energy source supplies. Market clearing assumptions are used to balance supplies against demand, and conversion process inputs against conversion process outputs. Primary energy sources flowing into the network and end-use energy sources flowing out of the network follow:

Primary Sources:

- Crude oil from Alaska and the Lower-48 states
- Other hydrocarbons and alcohol
- Wet natural gas production
- Coal production
- Nuclear, hydroelectric, geothermal, and other power
- Net imports of coal, crude oil, natural gas, and electricity

Conversion Processes:

- Refineries
- Natural gas processing plants
- Electric utilities
- Coke ovens

End-Use Energy:

- Motor gasoline
- Distillate fuel oil
- Residual fuel oil
- Jet fuel
- LPG and other petroleum products
- Natural gas by consuming sector
- Electricity by consuming sector
- Coal by consuming sector

The STIM is based on the premise that the U.S. energy system has the characteristics of a network through which primary energy production, energy conversion from primary to end-use form, and final consumption of energy can be monitored. By integrating the four energy subnetworks into a national network of energy flow, the STIM can illuminate the interactions among different types and forms of energy and their effects on the energy posture of the United States.

The variables and parameters in the STIM can be grouped into three functional classes: (1) the "drivers" consisting typically of demands and prices, crude oil supplies, electricity generation, and heating and cooling degree-days; (2) the variables and parameters that generally do not vary with scenario specifications such as net imports of coal, coke, natural gas, and electricity, and heat contents and heat rates of energy sources; and (3) the variables and parameters that are computed using the above values.

Aside from input and output, the STIM consists of two procedures called historical and forecast closure. Both of these procedures operate on the four energy subnetworks. The historical closure procedure uses the historical data base to check that historical energy supplies equal demands, tabulating any discrepancies that it finds by energy type. The forecast closure procedure adjusts both external and internal forecasts to balance predicted supply with predicted demand, and conversion process inputs with conversion process outputs. When the STIM completes forecast closure for all months in the forecast period, summary reports are prepared.

Within each of the four subnetworks, there are eight types of variables: primary fuel production, stock, net imports, flows to and from conversion processes, total supplies of finished products, demand for finished energy products, losses, and discrepancies (unaccounted for). Both the historical and the forecast closures follow the same steps with respect to each of the subnetworks. The electric utility subnetwork is closed first, then the natural gas subnetwork, next the oil and refining subnetwork, and finally the coal and coke subnetwork. Two sets of quantities must be accounted for before a closure is complete; the inputs and outputs of energy conversion processes and the final supplies and demands for each end-use

energy source. This accounting is accomplished in three steps for each month of data:

- Conversion process inputs are calculated from historical data pertaining to production, net imports, and stocks of primary energy sources.
- Total supplies of end-use energy sources are calculated from historical data pertaining to production, net imports, and stocks of end-use energy sources.
- Discrepancies between calculated final end-use energy source supplies and reported demands are determined.

The oil and refining subnetwork procedure ensures that component supply forecasts for crude oil and petroleum products add up to the corresponding demand forecasts, as well as balancing refinery inputs with refinery outputs. It also performs miscellaneous calculations for the natural gas, coal, and electric power sectors. It is designed to alter the input supply component forecasts as little as possible to achieve a balance. The inputs either are generated by procedures in the STIM or are read from external files. The procedure solves a quadratic programming problem subject to a set of equality constraints. The final forecasts of supply always equal the corresponding forecasts of demand, and the adjustments to the input forecasts are minimal. The adjustments made are spread over all the supply components.

MODEL CAPABILITIES—NPC PRICE TEST CASE

In the NPC price test case, crude oil prices increased above the EIA's base case for the first half of the year and below it for the second half of the year. This approximates the range experienced over the last year (Figure 2). Petroleum product prices follow crude oil prices. Because of seasonal factors and price lag effect from crude oil prices, gasoline prices peak in the second quarter. Also, due to the effects of seasonal factors and price lag, petroleum product prices are somewhat higher than the fourth quarter base case STEO prices even though the crude oil price is lower. The refiner acquisition cost in the NPC scenario was \$6 per barrel higher in the fourth quarter of 1990 than in the base case, which affected prices for the first several months of 1991.

Domestic oil production is expected to be higher, on average, than in the base case. The improvement is concentrated in Alaska, as development efforts are accelerated somewhat in late 1990 and early 1991. The Point Arguello field is included in the projections beginning January 1, 1991.

Coal prices were similarly affected as the oil price is a factor in mining and transporting coal to electric utilities. The higher coal prices and inflation rates resulted in higher electricity prices.

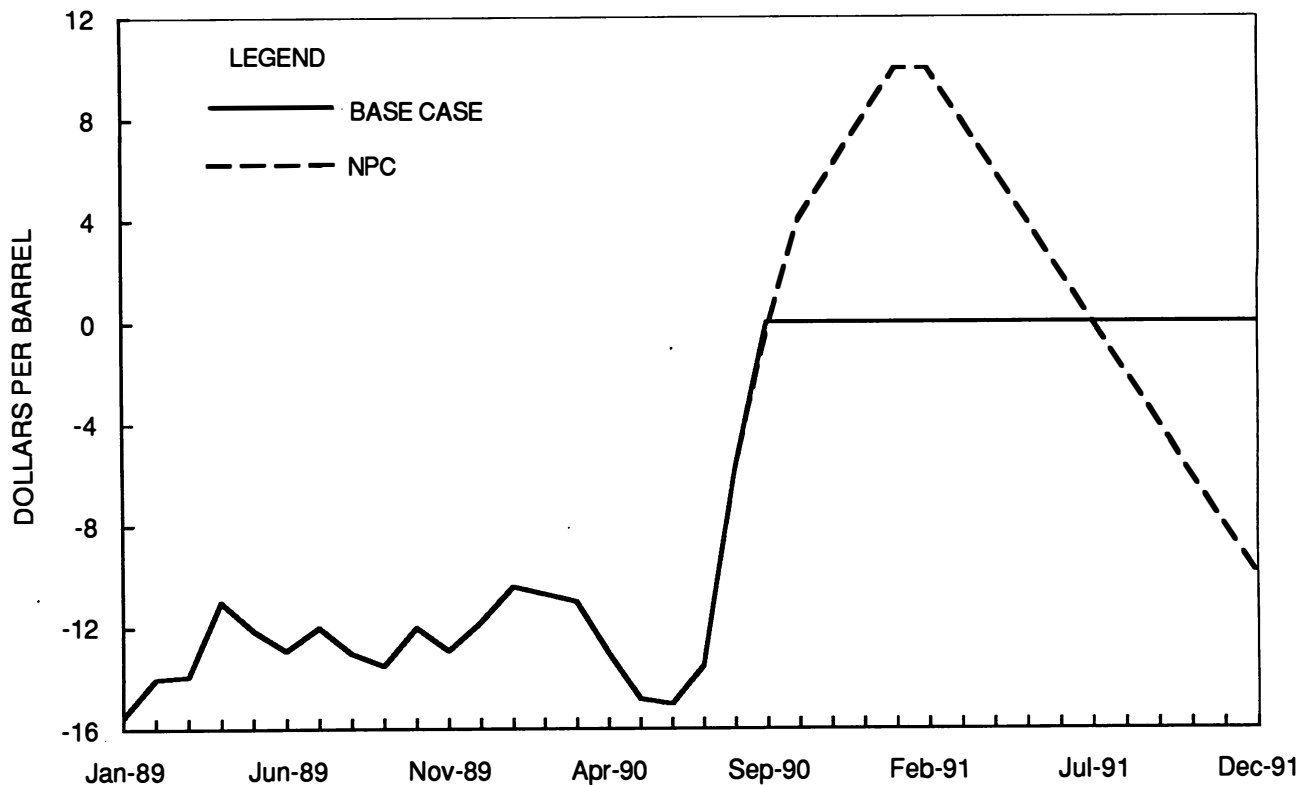


Figure 2. Crude Oil Price—Base Case vs. NPC.

Natural gas prices were generally lower than those in the base case STEO for the year as a whole. There were differences in the comparisons by quarter, particularly for the price to electric utilities. These prices were sensitive to residual fuel oil prices and, as a result, were considerably higher than the base case prices in the first quarter of 1991 but much lower in the fourth quarter. The wellhead prices and thus the residential prices were slightly lower in the NPC case (on average) due to lower demand, particularly in the latter half of 1991, caused by lower economic growth than that in the base case.

Although average crude oil prices for 1991 were only slightly above the level projected in the base case, the substantial upward spike in January resulted in crude oil prices substantially higher during the first half of 1991 than in the base case.

As a result, the NPC price test case model run resulted in a much weaker economic performance for the year. The run showed a smaller increase (0.3 percent) in real gross national product than in the base case (0.8 percent) (Figure 3). Accordingly, real disposable personal income declined by a sharper 0.6 percent compared to a more moderate 0.2 percent decline in the base case. Manufacturing production declined 0.7 percent versus flat growth in the base case.

Petroleum product demand is projected to decline by 4.9 percent in 1991 compared to 4.3 percent in the base case (Figure 4). Motor gasoline

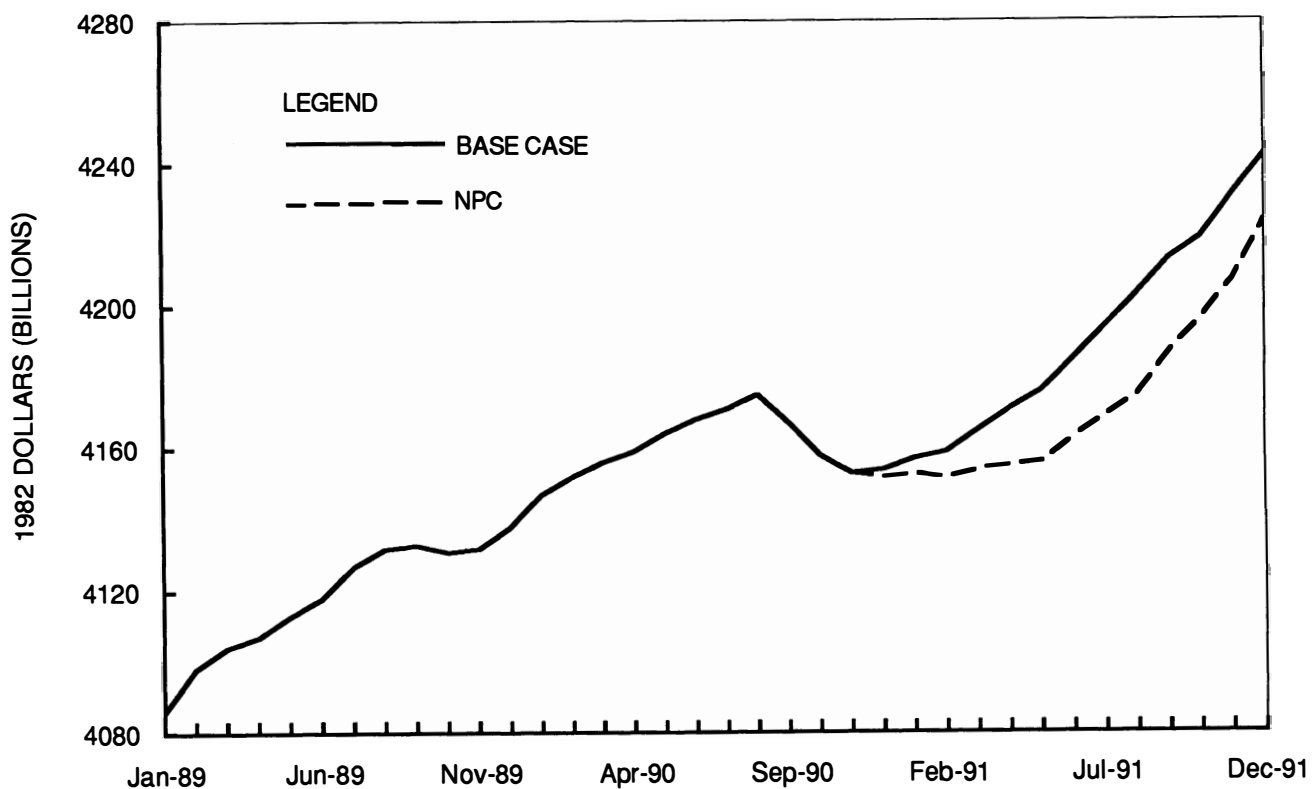


Figure 3. Gross National Product—Base Case vs. NPC.

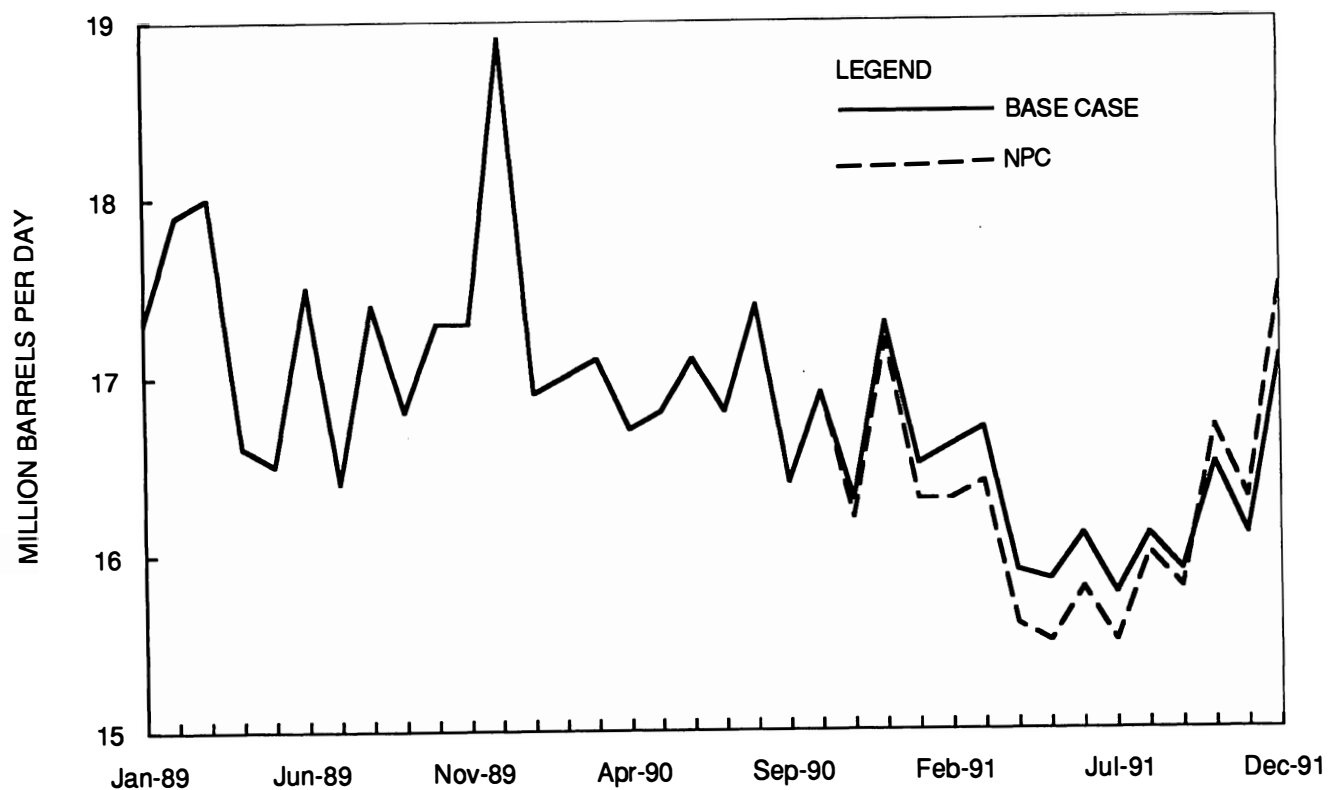


Figure 4. Total Petroleum Demand—Base Case vs. NPC.

demand declines by 4.3 percent versus 3.0 percent in the base case due to a combination of a decline in highway travel activity and boosts in fuel efficiency brought about by higher oil prices. Jet fuel demand declines by 5.0 percent versus 4.6 percent. Residual fuel oil demand declines by 16 percent. That is somewhat less than the 19 percent decline projected in the base case. Increases in demand brought about by low oil prices in the second half of 1991 more than offset the declines during the first half of the year due to fuel-switching asymmetries brought about by thresholds that limit the extent of declines associated with high oil prices. Distillate demand declines by 4.6 percent compared to 3.7 percent in the base case. Although the industrial sector accounts for only one-sixth of total distillate demand, it accounts for more than half of that downward shift. Transportation accounts for most of the rest of the difference. Other petroleum products decline by 2.8 percent in 1991, compared to 2.3 percent in the base case, as a result of a downward shift in petrochemical product output.

A summary of the test case results is shown below:

	1990	1991	
		Base Case	Test Case
Crude Oil Price, \$/bbl	22	30	20-40
GNP, %/Year	1.0	0.8	0.3
Industrial Production Index, %/Year	0.9	0.0	(0.7)
Disposable Income, %/Year	1.0	(0.2)	(0.6)
Demand, MMB/D			
Motor Gasoline	7.3	7.0	6.9
Jet Fuel	1.5	1.5	1.4
Distillate	3.0	2.9	2.9
Residual Fuel	1.2	1.0	1.1
Other	4.0	3.9	3.8
Total	17.0	16.3	16.1

The EIA was asked to document the details of the STIFS process as the effort progressed through all of its steps. The special NPC Price Test Case STIFS Run was accomplished during the 11/30/90-12/5/90 time frame (three working days) and was conducted by providing inputs and outputs for each key step taken in coming to a solution and by explaining how problems were identified and resolved. The time budgeted for the exercise did not allow for as extensive a review by analysts outside of the Energy Analysis and Forecasting Division as would be the case in a normal STEO cycle. However, the results were presented to the Office of Oil and Gas and the Office of Coal, Nuclear, Electric and Alternate Fuels; comments were received; and modification to the results were implemented where

necessary. New domestic oil production forecasts were obtained from the Dallas Field Office using the oil price trajectory assumed for the test case.

The STIFS integrated run results include the forecast demands and supply balances, plus any overrides in the third quarter of 1990 that may have been available from weekly data. In some cases, these overrides may not coincide with demand model tables, which do not have these historical estimates.

The key steps in the test case STIFS process comprised 15 sections as follows:

- New Oil Price Path
- First Round Price Run
- New Macroeconomic Solution
- Second Round Price Run
- First Round Demands
- Preliminary STIFS Integrated Balance
- Third Round Price Run
- Second Round Demands
- Review by the Office of Oil and Gas and by the Office of Coal, Nuclear, Electric and Alternate Fuels
- Second Round Integrated Balance
- Fourth Round Price Run
- Third Round Demand Run
- Third Round STIFS Integrated Balance
- Fourth Round Demand Run
- Final STIFS Integrated Balance

New Oil Price Path

The oil price path used in the NPC test case was chosen arbitrarily, but was designed to provide a trajectory that was distinct in direction and magnitude relative to base case STEO runs. The oil prices extend above the historical base case range at first, and fall steadily and sharply throughout the forecast period.

First Round Price Run

Using the new oil price path and the macroeconomic projections utilized in the base case STEO, an initial run of the price equations was done. The projected growth rates of these energy prices were used to change DRI Model counterparts so that a new macroeconomic solution would be as consistent with EIA assumptions as possible on a first pass. No regular report of this price case is typically saved.

This and all subsequent runs of the demand and price forecasting subsystem of STIFS were performed by the Supply Analysis and Integration Branch.

New Macroeconomic Solution

The macroeconomic projection for the NPC run was generated by resimulating the DRI/McGraw-Hill Quarterly Macroeconomic Model using the October 1990 CONTROL Simulation as a base.

In order to give an EIA flavor to the macroeconomic projections, the oil prices, as well as preliminary energy product prices (using the base case STEO macroeconomic assumptions), were used to modify DRI CONTROL factors for energy product prices to coincide more closely with EIA growth rates. This is the standard procedure for generating a base macroeconomic forecast for the STEO.

The oil price spike had the effect of reducing real GNP in 1991 by about 0.5 percent, compared to the fourth quarter macroeconomic case for the base case. Even though average nominal crude oil prices are not very different between the two cases, the spike induces a drop in confidence and general inflation fears, making consumers and producers more cautious than they otherwise would have been in the short run.

The macroeconomic solution, as with all regular STEO runs, was performed by the Economics and Statistics Division. They receive the preliminary prices, downloaded to a diskette, in deseasonalized form (to be consistent with the macroeconomic model counterparts). The quarterly growth patterns of these prices (e.g., retail motor gasoline price in STIFS corresponding to DRI's consumption deflator for residential motor gasoline use) are calculated and used to generate changes in DRI counterparts. A routine is used to generate new factors in the DRI model that will ensure close approximation to the EIA price paths.

Second Round Price Run

The second round price run utilized the new macroeconomic forecast (principally to get an update on inflation, as this affects nominal product prices), as well as the new oil price path. This price case is the first one which is examined extensively for anomalies.

No problems were identified initially; however, it was recognized that residual fuel oil prices would have to be lowered using the price feedback mechanism set up for the base case. This is done after the preliminary integrating run is completed.

It was thought at first that residential electricity prices might be too high. However, it was concluded that, as a first pass, it probably was in line with the change in inflation and nominal fossil fuel price increases.

First Round Demands

The first round demands produced generally acceptable results, but turned up some minor problems with distillate fuel oil and residual fuel oil that needed to be addressed.

For distillate fuel oil, a problem became apparent in the fourth quarter of 1991 results, when residential and commercial use rose rapidly. The direction was correct for that quarter but seemed asymmetrical compared to the previous quarters. The distillate model had incorporated an ad hoc adjustment to the residential/commercial sector to allow for likely conservation and accelerated conversions to natural gas heat that was not incorporated before. This fix was adequate as long as one had flat or monotonic price changes. The ad hoc fix was altered so as to be more general and the results, while not drastically different, seemed to be more consistent with expectations.

For residual fuel, the third quarter 1991 results indicated a change in utility residual fuel use that was in the wrong direction compared to what was expected given the price movements. The utility fuel share routine was examined and some hardwired upper and lower price limits, which were appropriate for the base case but not appropriate for the NPC run, were the problem. The limits relate to resid/natural gas price ratios and were designed to set the range through which residual fuel oil use would be reduced or increased, at the expense of gas, subject to recently observed minimum and maximum utility oil shares. The routine was acceptable for the parallel price paths used in the base case, but a more general version of the routine was needed to handle the NPC case. A correction was incorporated prior to the second round demand runs.

Concerning the residual fuel oil results, the question arose as to whether or not the apparent asymmetry by quarter was appropriate. This result was due entirely to the utility sector and the assumption that the maximum reduction in oil use had already been achieved and no further reduction would be likely even if much higher prices prevailed. Since non-utility gas demand was reasonably determined to be higher in the NPC case than in the base case, it was concluded that nothing would have improved for the winter months, as far as gas deliverability was concerned. At this point in the process, the EIA analysts felt that the residual fuel oil result was reasonable.

Preliminary STIFS Integrated Balance

The preliminary integrating run revealed several areas of concern. This run, along with the second round demand and third round price runs, was submitted for analysis in the EIA's Office of Coal, Nuclear, Electric and Alternate Fuels and Office of Oil and Gas for review.

EIA analysts noticed that while things generally went in the right direction, crude oil runs had a rather odd seasonal pattern, showing increased or high runs in the first quarter even though demands were noticeably lower. Also, residual fuel oil stocks at the end of 1991 fell off more sharply than seemed reasonable. It was suspected that some of the constraints placed on the supplies of residual fuel oil (both net imports and refinery outputs) in STIFS for the base case were to blame for the latter

problem. The crude oil problem required some rethinking of the methodology. The resolution of these problems is discussed following the Third Round Price Run and Second Round Demand Run comments below.

Third Round Price Run

Before making necessary changes to the first round integrated balance, a third round price run was performed which incorporated a new residual fuel oil price equation. This equation made use of the residual fuel stocks estimates (from the previous integrated balance) relative to demand to push resid prices up (down) whenever resid supply was relatively scarce (plentiful). The first round resid price was calculated using the old residual fuel price model, which essentially follows crude oil prices. The resulting residual fuel oil margin in 1991 was reduced lower than historical averages but well in line with the experience of middle to late 1990.

Second Round Demands

The second round demand runs appeared to eliminate the distillate and residual fuel anomalies mentioned in the discussion of the first round demands. The overall demand levels were changed very little from the first round in this run, although the quarterly patterns for distillate and residual fuel were changed somewhat. Non-utility residual fuel demands increased in the spring and summer, as this is where the resid feedback equation generated the biggest reduction in resid prices. The opposite effect correctly showed up in the first quarter 1991 results.

At this point, the EIA analysts believed that the general direction of the forecast was good and the responses to the shifts in prices and economic environment appropriate.

Review of the Forecast by the Office of Oil and Gas (O&G) and the Office of Coal, Nuclear, Electric and Alternate Fuels (CNEAF)

At this point, copies of the first round integrated balance, third round price forecast, and second round demands were sent to the O&G and CNEAF offices, which agreed to supply reviewers of the STIFS NPC runs. The first pass of the integrated forecast would not normally go out for EIA review.

The Office of Oil and Gas provided the following comments:

- The Petroleum Supply Division noted agreement on the problem of the odd seasonal pattern of crude oil production and product imports, questioning why, under decreasing demands, imports would increase as runs fell.
- Refinery gains did not track crude oil inputs as expected.
- Other hydrocarbons and alcohol inputs have an unusual pattern considering their likely relationship to gasoline vapor pressure.

- The Reserves and Natural Gas Division (RNGD) felt strongly that wellhead gas prices were generally too high, especially in the latter part of 1991, when gas demand was weakening and oil prices dipped to low levels. This was not a surprising comment since, up until this point, no change from the base case had been assumed for wellhead gas prices.
- RNGD also pointed out that end-use gas price margins over wellhead costs were higher for the NPC run compared to the base case, and this seemed unreasonable since the economy was weaker and the oil price rise was temporary.

In response to these comments with respect to crude oil inputs, a fresh look was taken at the equation that produces initial estimates of crude oil runs to see if more reasonable seasonal patterns could be ensured, while still allowing for the effects of shifting demand patterns on utilization rates. A new equation was developed and included in the integrating model, which tends to give a much more normal seasonal pattern to crude oil runs than the version used in the base case. It also gave much lower crude oil runs overall in 1991 than were generated in the first round integrating balance. It was decided that the new equation would be used only to generate the seasonal pattern for runs, and to keep total annual crude oil runs at about the rate indicated in the initial integrated run for the NPC case.

The residual fuel oil problem was addressed in two ways. First, the original forecast for resid output (before petroleum balancing) was adjusted by half the change in resid demand from the base case to the NPC scenario (e.g., if demand was 20 percent below the base case demand, then resid output was set at 10 percent below the base case). This adjustment was based on informal analysis which suggested that a 50 percent adjustment rate for output relative to demand fit well with historical experience. Second, the minimum yield of residual fuel oil per barrel of crude oil input to refineries was increased. This correction affected only August and September of 1991.

It was felt that the RNGD comments on gas prices were reasonable and a plan was developed to adjust those prices accordingly. Wellhead gas prices were adjusted in a way that made the changes relative to crude oil price similar to the way in which year-to-year changes in wellhead gas prices tracked similar changes in oil prices.

The CNEAF office indicated that the residual fuel oil demand increase at utilities for 1991, when resid prices were higher and gas availability still rather good, did not make sense. While it was thought that the apparent inconsistency in these results could be explained by the quarterly price patterns (demand does not increase until the end of 1991, when oil prices are quite low), it is possible that the magnitude of the resid demand increase in the fourth quarter of 1991 is extreme. The notion may have

merit because gas demand is expected to be weak in that quarter in non-utility sectors, thus possibly implying good availability. However, no plan to change these numbers was implemented by the EIA analysts.

Second Round Integrated Balance

The second round integrated balance used the second round demand results, new crude oil production figures from the Dallas Field Office (using the new oil price assumptions), the new equation for crude oil runs, and a correction to ending residual fuel oil stocks for 1991 (refinery outputs of residual fuel oil increased).

The runs pattern looked more reasonable here. With demands for most fuels (except resid and distillate) down sharply, and with fuel oil stocks assumed to be more than adequate at year-end 1990, the significant reduction in the first quarter 1991 crude oil runs was appropriate.

Fourth Round Price Run

The fourth round price run implemented the new assumptions on wellhead gas prices derived from consultation with the Reserves and Natural Gas Division.

A correction to residential electricity prices, which had been overlooked in earlier runs, was incorporated during this step. This put annual average electricity rate increases more in line with expectations generated by the more detailed results of EIA's mid-term electricity supply model.

Third Round Demand Run

The third round demand run implemented the fourth round price results. Unfortunately, an error occurred here, in that the old distillate model was mistakenly used rather than the modified one described in the discussion of round one to round two demands. This problem was corrected by the EIA analysts with an additional computer run.

Third Round STIFS Integrated Balance

The third round integrated run was not evaluated by the EIA analysts because of the third round demand error.

Fourth Round Demand Run

The fourth round demand run reinstated the new distillate model. The end result for demands was not much different from the original run, about 130 MB/D lower than the base case results for total petroleum demand. This difference was in line with expectations based on the known sensitivities of the STIFS model to macroeconomic and price changes.

Final STIFS Integrated Balance

For the final integrated run balance, three additional changes were made, two to bring residual fuel oil stocks more in line with expectations. The first of these changes addressed residual fuel oil net imports. In the base case, a cap had been put on residual fuel net imports. This fix was necessary because the base case runs tended to exaggerate the seasonality of residual fuel oil demand (i.e., lower in the spring and summer). Normal rates of imports tended to yield high excess stocks in the off-quarters, and a mechanism was needed to limit this. The cap proved to be too rigid for the NPC run, and it was changed so as to be one-third of total residual oil demand. In addition to this change, the weight assigned to residual fuel oil stocks in the balancing algorithm was raised significantly. This change had the effect of reducing the tendency of the balancing routine to move away from initially specified stock targets.

The third change addressed the Other Hydrocarbons and Alcohol forecast. These categories were changed in proportion to gasoline shipments.

MODEL CAPABILITIES—NPC ECONOMIC TEST CASE

In the NPC economic test case, the demand and price models of the STIFS were run using an update to the macroeconomic forecast that had been included in the fourth quarter 1990 STEO. This run of the Unified Demand and Price Analysis Subsystem (UDAPAS) also included the latest historical demand and price updates. The starting point in the updated macroeconomic forecast was the DRI/McGraw-Hill November 1990 CONTROL. In terms of the routine quarterly STIFS process, this test case effort represented the first steps in producing a STEO. The details of the process have been outlined previously in the NPC Price Test Case section.

A summary of the test case results is shown below:

		<u>1991</u>	
	<u>1990</u>	<u>Base Case</u>	<u>Test Case</u>
Crude Oil Price, \$/bbl	22	30	30
GNP, %/Year	1.0	0.8	(0.3)
Industrial Production Index, %/Year	0.9	0.0	(2.2)
Disposable Income, %/Year	1.0	(0.2)	(1.0)
Demand, MMB/D			
Motor Gasoline	7.3	7.0	7.0
Jet Fuel	1.5	1.5	1.5
Distillate	3.0	2.9	2.8
Residual Fuel	1.2	1.0	1.0
Other	4.0	3.9	3.8
Total	17.0	16.3	16.1

The test case energy demand results all changed in expected and rational patterns consistent with the models previously reviewed. The absolute levels of the resulting changes are reasonable in all cases.

OBSERVATIONS

The STEO (U.S. and international) process is an interactive process that should yield reasonable results. With the current configuration of the EIA's outlook organization and status of models, there is no expectation that results will be outside a normal range of study uncertainty.

There are several areas in the mathematical models used for the U.S. projection that, if modified, could improve performance.

- The most significant concern is the apparent aggressive short-term crude oil production response to price. In-depth questioning about results shown in the fourth quarter 1990 STEO indicated a rationale for crude oil production response to price that was largely non-economic. Non-economic factors should be identified in published reports.
- The representation of natural gas substitution for oil consumption appears to be driven only by the relative price of the two energy forms. Aside from direct analyst intervention, there is no clear indication that the fuel switching limitations of facilities capable of consuming both fuels or the limitations on the deliverability of the natural gas are incorporated.
- The representation that results in the division between electric utility distillate and residual fuel oil use appears very limited. Constraints imposed by turbine use versus boiler use of these fuels are not depicted in the models.
- While not directly part of the mathematical models, the high degree of analyst interaction required could be a shortcoming without a high experience level of the EIA staff. Currently, this is not an issue.

The international segment of the STEO process relies almost entirely on successful interaction between EIA analysts and industry personnel. Consequently, the need for very experienced personnel in this activity is critical. Currently this is not an issue. The addition of mathematical models might provide support in this area. However, the potential benefit could be offset by the need for experienced analysts to build and maintain these models.

The STEO process is designed for production of an outlook on a quarterly basis. However, the preparation elapsed-time requirement can be reduced to several days as demonstrated during the development of the NPC test cases. Despite the compression of the preparation schedule, the results developed from the test cases are reasonable.

APPENDICES

APPENDIX A

REQUEST LETTER AND
DESCRIPTION OF THE
NATIONAL PETROLEUM COUNCIL



The Secretary of Energy
Washington, DC 20585

October 19, 1990

Mr. Lodwrick M. Cook
Chairman
National Petroleum Council
1625 K Street, NW
Washington, DC 20006

Dear Mr. ^{Lod} Cook:

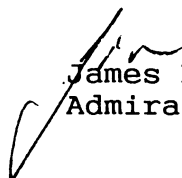
Since the Iraqi invasion of Kuwait on August 2, 1990, and in light of the impending National Energy Strategy (NES) completion, the Department of Energy has been analyzing the world refining situation and its impact on U.S. supplies and markets. Your report last year on Petroleum Storage & Transportation, especially its volume on System Dynamics, has proven particularly helpful to our understanding of the workings of the petroleum distribution systems. In addition, we have been gratified by the responsiveness of the U.S. petroleum industry to our requests for information on a variety of topics.

As we begin testing the Strategic Petroleum Reserve (SPR) and looking ahead to this winter's heating season and next summer's driving season, I would like the Council's assessment of the issues shaping the short-term supply/demand outlook. Specifically, I request that the National Petroleum Council provide, at the earliest possible date, quarterly supply and demand estimates for petroleum crude and products through June 30, 1991, and an analysis of the factors that can affect those estimates. Your assessment should consider such factors as crude availability and quality, refinery utilization and impact of turnaround schedules, regulatory impediments to reactivating mothballed refineries, product exports and imports, inventory draw/build and use of the SPR.

I understand that a request of this nature can involve competitive company information and can require assumptions in legally sensitive areas. To the extent it will be helpful for your analysis, we will make available to you the assumptions and results of the Energy Information Administration's Short-Term Energy Outlook.

For the purpose of this study, Linda G. Stuntz, Deputy Under Secretary for Policy, Planning and Analysis, will represent me and provide the necessary liaison with the Department of Energy.

Sincerely,


James D. Watkins
Admiral, U.S. Navy (Retired)

DESCRIPTION OF THE NATIONAL PETROLEUM COUNCIL

In May 1946, the President stated in a letter to the Secretary of the Interior that he had been impressed by the contribution made through government/industry cooperation to the success of the World War II petroleum program. He felt that it would be beneficial if this close relationship were to be continued and suggested that the Secretary of the Interior establish an industry organization to advise the Secretary on oil and natural gas matters.

Pursuant to this request, Interior Secretary J. A. Krug established the National Petroleum Council on June 18, 1946. In October 1977, the Department of Energy was established and the Council was transferred to the new department.

The purpose of the NPC is solely to advise, inform, and make recommendations to the Secretary of Energy on any matter, requested by him, relating to oil and natural gas or the oil and gas industries. Matters that the Secretary of Energy would like to have considered by the Council are submitted in the form of a letter outlining the nature and scope of the study. This request is then referred to the NPC Agenda Committee, which makes a recommendation to the Council. The Council reserves the right to decide whether it will consider any matter referred to it.

Examples of recent major studies undertaken by the NPC at the request of the Secretary of Energy include:

- *Refinery Flexibility* (1980)
- *Unconventional Gas Sources* (1980)
- *Emergency Preparedness for Interruption of Petroleum Imports into the United States* (1981)
- *U.S. Arctic Oil & Gas* (1981)
- *Environmental Conservation—The Oil & Gas Industries* (1982)
- *Third World Petroleum Development: A Statement of Principles* (1982)
- *Petroleum Inventories and Storage Capacity* (1984)
- *Enhanced Oil Recovery* (1984)
- *The Strategic Petroleum Reserve* (1984)
- *U.S. Petroleum Refining* (1986)
- *Factors Affecting U.S. Oil & Gas Outlook* (1987)
- *Integrating R&D Efforts* (1988)
- *Petroleum Storage & Transportation* (1989).

The NPC does not concern itself with trade practices, nor does it engage in any of the usual trade association activities. The Council is subject to the provisions of the Federal Advisory Committee Act of 1972.

Members of the National Petroleum Council are appointed by the Secretary of Energy and represent all segments of the oil and gas industries and related interests. The NPC is headed by a Chairman and a Vice Chairman, who are elected by the Council. The Council is supported entirely by voluntary contributions from its members.

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JONES, Jon Rex
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APPENDIX B

STUDY GROUP ROSTERS

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APPENDIX C

EIA: *PETROLEUM PRICES AND PROFITS IN THE 90 DAYS FOLLOWING THE INVASION OF KUWAIT*

OVERVIEW

EXTRACTED FROM EIA REPORT,
*PETROLEUM PRICES AND PROFITS IN THE 90 DAYS
FOLLOWING THE INVASION OF KUWAIT,*
NOVEMBER 1990.

INTRODUCTION

Overview

For the third time in the past 20 years the world has experienced an interruption in the flow of oil from the Persian Gulf. The Iraqi invasion of Kuwait on August 2, 1990, and the shut down of Kuwaiti oil production capacity followed by the United Nations boycott of Iraqi oil removed 8 percent of the world's oil supply. The result was a sharp increase in the price of crude oil and petroleum products. These events raised numerous questions about the performance of energy markets and energy firms.

This report supplies a first answer for some of those questions. At the time this report was prepared the invasion has been in effect for 90 days. Not all the data is available to fully answer every question. Some issues can only be completely resolved after more time has passed in which the invasion and its effects have had an opportunity to be fully assimilated.

This report was specifically requested by W. Henson Moore, Deputy Secretary of Energy as a way of supplying the American public with what could be said about the current situation. Rumors abound and misconceptions have proliferated. This report strives to give a proper perspective on some of the more vexing issues which the invasion produced.

The Energy Information Administration (EIA) has addressed many questions in this report. By way of summary these are the 10 most frequently asked questions and EIA's quick answers. The page references tell the reader where to look in the report for further explanation. These are not the only issues addressed and EIA hopes that readers will be able to satisfy their curiosity about their own questions within the pages of this report.

The 10 Most Frequently Asked Questions

Question 1: **At the time of the invasion how dependent was the U.S. on imported oil and how much of that came from Iraq and Kuwait?**

Answer: The United States imported 46 percent of its oil products with 5 percent of consumption coming from Iraq and Kuwait. (Page 1-2)

Question 2: **What determined the price of crude oil and petroleum products after the invasion?**

Answer: Prices of oil during the disruption have been determined by supply and demand and expectations of changes in supply and demand. There is no indication that markets failed to work. (Page 3-1)

Question 3: What caused the rapid increase in crude oil prices immediately following the invasion?

Answer: Oil prices rose rapidly because of the 4.3 million barrel a day loss caused by the invasion. It was not clear if other nations would increase output to offset the shortfall or if the war would spread, further reducing the supply of petroleum products. (Page 3-2)

Question 4: Why did oil prices remain high when replacement oil began to reach the market?

Answer: Prices for oil remained high because of uncertainties. Most of the replacement crude was coming from the Persian Gulf, primarily Saudi Arabia, which is adjacent to Kuwait. The possibility of war maintained high oil prices. (Page 3-3)

Question 5: Was the increase in the retail price of gasoline more or less than the increase in crude oil prices would have justified?

Answer: In the United States retail gasoline prices did not increase as fast as the price of crude oil. At the end of the 90 days, increases in pump prices were below but approaching the increase in the price of crude oil. (Page 1-3, 3-5)

Question 6: How did the invasion affect the prices of heating oil and jet fuel?

Answer: Prices of fuel oil rose in proportion to the increase in crude oil prices. Jet fuel (kerojet) prices increased by more than the price of crude oil due to the loss of Kuwait's refinery capacity (a major source of jet fuel), and increased military demand. (Page 3-6)

Question 7: Did prices for petroleum products increase as much in other countries as they did in the United States?

Answer: In Europe and Japan prices rose more quickly than in the United States. Prices also fell more quickly there than here when crude oil prices declined. (Page 1-3)

Question 8: How did oil company profits change because of the invasion?

Answer: For the months of July, August, and September oil company profits showed mixed results. Companies which owned a significant amount of the crude oil they needed saw profits rise. Companies which had to buy crude oil or petroleum products at the higher prices were hurt. Price restraint at the retail level reduced profits. There is no evidence of industry wide profiteering during this period. (Page 4-1)

Question 9: Who benefitted because of the increase in crude oil prices following the invasion?

Answer: The beneficiaries of the increase in crude oil prices were those who produced oil or held large inventories of oil. Most oil is owned by foreign interests, principally governments. Eighty percent of the world-wide benefit went to those outside the United States. (Page 4-5)

Question 10: Were speculators in futures markets responsible for the increase in oil prices?

Answer: Most of those participating in the futures market were firms who used oil (refineries, airlines, chemical companies) who wanted to guarantee prices and supply for their customers. Speculative activity in oil declined during the first 90 days of the invasion. (Page 5-4)

Limitations

This 90-day analysis utilizes immediately-available data from either EIA collections or public sources. As always, there is a trade-off between providing timely analysis and accuracy as well as depth of coverage. The report focuses on trends in the world oil markets, crude oil and petroleum product prices, and industry profits recognizing the preliminary nature of some data presently available. An attempt was also made to present this information in a manner understandable by the wide audience which has an interest in the current situation. For that reason tables have been placed at the end of the report in Appendix A and are only referenced in the text. The figures in the text have back up tables in Appendix B. EIA plans to do a more comprehensive analysis of this situation when more detailed data are available. Most EIA data are collected on monthly cycles and availability usually lags about 2 months (currently only August monthly data are available.) EIA does not expect that the more comprehensive analysis will substantially alter the trends and conclusions presented in this preliminary report.

APPENDIX D

NPC: *SYSTEM DYNAMICS*

EXECUTIVE SUMMARY

AND

VALIDATION BY RECENT EVENTS

EXTRACTED FROM NPC REPORT,
PETROLEUM STORAGE & TRANSPORTATION;
VOLUME II—SYSTEM DYNAMICS,
APRIL 1989.

EXECUTIVE SUMMARY

This summary provides a brief overview of the National Petroleum Council's examination of the dynamics of the oil and natural gas distribution system. While concern was focused on the U.S. distribution system and its changes, the NPC also dealt with international issues, because the United States is an integral part of the world supply system. This study examined comprehensively two types of changes that occur -- or might occur -- in the supply-demand system and the industry capacity to respond. These two types of changes include:

- Long-term economic trends that cause continuing -- but not sudden -- shifts in the distribution patterns of crude oil, finished products, and natural gas throughout the market.
- Short-term and sudden shifts or crises in either supply or consumption of crude oil, finished products, and natural gas. Such crises might include the sudden and complete disruption of a major pipeline or the unexpected upsurge in demand because of weather or some unusual, unpredictable event.

Events over time demonstrate that the system for the distribution of petroleum (crude and refined) and natural gas is both resilient and flexible. As demand and supply have ebbed and flowed and shifted geographically, the system has readjusted itself by fresh allocation or switching of investment to cope with the evolving changes and short-term operating adjustments. Most notable has been the ability of the system to readjust to compensate for the closing of over 100 U.S. refineries in the past seven years. The fact that this could be accomplished without product outages in the marketplace is testimony to both the resilience and flexibility of the system.

In addition, the system has the built-in flexibility and reserves to cope with a broad variety of sudden disruptions to either supply or demand. To test this capability, the NPC examined six possible disruption scenarios to determine how the system might respond. The scenarios represented a realistic mix of the "bad things" that might happen to disrupt the flow of crude oil, product, and natural gas or to significantly change demand. In each case, the system was found to be capable of repositioning supply and/or repairing the system in time to prevent any significant disruption of supply to consumers.

Three important overall conclusions about the petroleum distribution system emerged from this study:

- There is a built-in supply cushion or reserve that can be used to overcome possible disruptions, because the system supply lines are far-reaching both via ocean and

pipeline. In addition, inventory storage cushions at strategic points along the way help absorb short-term fluctuations.

- Should a mechanical disruption occur in a pipeline, for example, the means exist in many cases to quickly fix the line or circumvent it. In part, the great strength of the petroleum distribution system lies in its inter-connectability, and thus the availability in most cases of one or more alternative supply routes.
- As longer-term trends evolve, there are built-in financial incentives to invest capital to meet new and changing demands. Examples include: reversing the flow of a pipeline, looping a system (building a parallel line), building new pipelines, or developing a deep-water port. These are illustrations of how investment gets realigned or made fresh to meet changing conditions.

It is important to note that the driving force behind the system's capacity to readjust is the economic incentive of the free market. In a free market, as supply and demand ebb and flow, price also moves, encouraging either an increase in supply movement or a diminution in consumption.

The remainder of this summary consists of two parts. First, an examination of the longer-term trends the NPC has studied over the past decade to determine how, and with what success, the system has adjusted to cope with changing system requirements. Second, a brief look at each of the six hypothetical crisis scenarios designed to determine how the system reacts to violent, short-term shifts in either demand or supply.

EXAMINING THE LONGER-TERM TRENDS

Oil

It is important to establish at the outset that the domestic and international petroleum industries (which are inexorably intertwined) have experienced severe volatility and uncertainty in the past decade. Indeed, recent years have been difficult ones, and as a result the industry has experienced dramatic changes in its supply system.

Since 1979, the industry has passed through two significant periods. First, from a supply-and-demand high point in 1978-1979, the nation entered a period of great conservation with U.S. consumption falling off from a 1978 high of 18.8 million barrels per day (MMB/D) down to a low of 15.2 MMB/D in 1983 before gradually rising to 16.7 MMB/D in 1987. This was a frenzied period in which drastic price rises were anticipated, encouraging expensive searches for alternative energy sources. This also was the period of the Iranian oil cut-off when both oil and natural gas

supplies were expected to be inadequate. That expectation was premature; West Texas sour crude oil prices hit a high of \$36 per barrel in 1980 before plunging to a low of about \$10 per barrel in 1986. The impact on U.S. exploration and production was harsh.

Despite the volatility of price, demand, and supply (particularly shifts in source), only minimum disruptions were felt by the consuming public or commercial enterprises. Perhaps the only consequences of note that many people remember were the gasoline lines for a brief period in 1979.

The second stage began in 1983-1984 with the gradual increase in petroleum demand, with a recovery to 16.7 MMB/D by 1987. Demand for petroleum products also rose gradually in the rest of the world. Prices during this period generally decreased. During this period, OPEC had a significant production surplus, which eventually appeared in the market. The price crash in 1986 badly hurt exploration and production in the United States. OPEC continues to be a significant factor, whose influence is unlikely to diminish soon. Again, this second stage, 1983-1987, was a period of uncertainty and volatility. One can hope for price stability at some reasonable level; but no one is willing to count on it.

Under these trying conditions, the petroleum (crude oil and product) distribution system performed remarkably well. There were no significant disruptions in petroleum supply to any part of the U.S. economy during this second stage.

During the period from 1979 to 1988, major changes took place in the petroleum supply system. These changes included:

- Regulation -- January 1981 marked the end of price and allocation regulations. These regulations, which had a stultifying effect on the industry, reduced both the benefits and risks of competition. However, in 1981 the industry went back to full-bore competition in a period when demand was dropping.
- Crude Oil Production and Imports -- Average annual crude oil production rose from a low of 8.1 MMB/D in 1976 to a high of 9 MMB/D in 1985, in large part because of the growth of Alaskan production. In 1987, it fell to 8.3 MMB/D and is still declining. However, U.S. demand is rising, resulting in increased imports of foreign crude oil.
- Change in Product Mix -- Both tightened environmental regulation and inter-fuel price competition have significantly changed the mix of products needed to serve consumers. One major swing has been a drop of over 1.75 MMB/D in the demand for residual fuel oil since 1978, even though a small recovery is projected for the future. This has been replaced by natural gas and even

coal in some cases. In contrast, the demand for gasoline and distillates has risen by 0.9 MMB/D since 1983.

- Refining Capacity -- One of the most dramatic changes has been a significant reduction in crude oil refining capacity in the United States. Between 1981 and 1986, over 100 refineries were closed. In 1981, the industry had a refining capacity of more than 18 MMB/D. Current refining capacity is less than 16 MMB/D, but in general it is more efficient and more economical capacity. Because refining throughput and refinery location largely determine the movement of crude oil, these changes have had a substantial impact on the distribution system and its performance.
- Petroleum Transportation and Inventory -- Declining demand and lower domestic production altered demand on the U.S. pipeline system. For example, the Texoma and Seaway pipelines were switched from crude oil to gas. Also, the decline in crude oil price altered the expectations of future price improvement and thus changed the economics of carrying inventory. As a result, system inventories of crude oil and product went from a high of 1,300 million barrels to just below 1,000 million barrels in 1985.

Natural Gas

Natural gas plays a vital role in our energy distribution system for two important reasons. First, gas fulfills some 23 percent of our energy needs primarily in residential and commercial heating and in industrial processing and electric generation. Second, depending on price and availability, some users switch back and forth between gas and residual fuel oil. Thus, the ability of the system to ensure gas availability is vital to our economy in itself but further affects increases or decreases in the demand for residual fuels.

The changes in the natural gas industry reflect a similar supply-demand cycle to that experienced in the oil industry -- i.e., increasing demand followed by a period of conservation and diminished demand. Gas consumption attained a high of nearly 22 trillion cubic feet (TCF) in 1972, driven by low regulated wellhead prices. In 1973, wellhead prices averaged \$0.22 per thousand cubic feet (MCF). Such low prices led to a fall in proved natural gas reserves, from almost 300 TCF in 1967 to about 200 TCF by 1978. Following the passage of the Natural Gas Policy Act (1978), average wellhead gas prices reached \$2 per MCF in 1981 and \$2.50 in 1982, while prices of some deregulated categories of gas ran up to \$10 per MCF at the time. Average U.S. consumer gas prices peaked in 1984 at \$4.85 per MCF, when wellhead prices peaked at \$2.66 per MCF.

Natural gas consumption declined during the late 1970s and early 1980s, reaching a low of about 16 TCF in 1986. Pipelines

and other distribution facilities became significantly underutilized. Also, decreasing demand resulted in a substantial surplus of domestic production capacity (the so-called "gas bubble"). Competition resulted in gas prices falling below regulatory ceilings. Demand for natural gas has increased in recent years. In 1987, natural gas consumption rose 1 TCF and it appears to have exceeded 18 TCF in 1988.

These undulations in supply and demand put a strain on the distribution system. In addition, the problems associated with these changes were greatly aggravated by continued tight regulation by the federal government. Until 1978, the overall effect of this regulation was to hold gas prices at artificially low levels that did not support exploration and replacement of gas reserves. To attempt correction, the government phased through a series of regulations that have moved the gas industry closer to a competitive, market-oriented business. However, this transition has been painful for the industry. The transition continued in 1988; but most major problems were being resolved and most producers had some improved access to the market on competitive terms.

In addition to the federal government, state agencies such as public utility commissions continued to be dominant in natural gas and other energy matters. The utility commissions testify in federal rate case hearings, review the flow-through of costs on new supplies of natural gas, and survey the supplies of natural gas moving to the end-user. Consequently, the local distribution companies (LDCs) and interstate pipeline companies continue to be sensitive to the actions and needs of not only state utility agencies but also state and municipal environmental, archaeological, land use, and other agencies.

It is notable that throughout the turmoil of the past 10 years, a most creditable job was done in transmitting gas to end-users, particularly to preferred users such as residences, hospitals, schools, and other public institutions. An important lesson emerges from this experience. There is no perfect system, but it is clear that the supply stream functions more effectively when the incentives of the free market are in play.

THE SUPPLY SYSTEM UNDER NORMAL CONDITIONS

One must recognize that the rapid changes in the oil industry over the past decade reflect the continuing business environment for the supply system. The successful supply performance is clear testimony to the response capability and adaptability of the system. As part of this study, the NPC also examined the ability of the system to handle industry growth through 1992.

To examine future supply capability, the study used the Department of Energy (DOE) forecast for 1992, as shown in Table 1. It is interesting to note that 1992 demands for crude oil and petroleum products are not projected to reach the

TABLE 1

U.S. OIL AND GAS DEMAND AND SUPPLY*

	<u>Actual</u> <u>1979</u>	<u>Actual</u> <u>1987</u>	<u>Projected</u> <u>1992</u>
<u>Oil Demand</u>	(Thousands of Barrels per Day)		
Gasoline	7,034	7,206	7,330
Distillate	3,311	2,976	3,440
Residual Fuel	2,826	1,264	1,470
Others§	<u>5,342</u>	<u>5,219</u>	<u>5,480</u>
Total Oil Demand	18,513	16,665	17,720
<u>Oil Supply</u>	(Thousands of Barrels per Day)		
Crude Petroleum	8,552	8,349	6,870
Crude Imports¶	6,519	4,674	7,060
Product Imports	1,937	2,004	2,300
Other**	<u>1,505</u>	<u>1,638</u>	<u>1,490</u>
Total Oil Supply	18,513	16,665	17,720
<u>Gas Demand</u>	(Billion Cubic Feet)		
Residential	4,958	4,302	4,597
Commercial	2,770	2,392	2,672
Industrial	6,807	5,827	6,420
Electric Utility	<u>3,462</u>	<u>2,814</u>	<u>3,228</u>
Subtotal	17,997	15,335	16,917
Lease and Plant Fuel	1,486	1,033	956
Pipeline Fuel	<u>600</u>	<u>517</u>	<u>527</u>
Total Gas Demand§§	20,084	16,885	18,400
<u>Gas Supply</u>	(Billion Cubic Feet)		
Dry Gas Production	19,443	16,295	17,280
Net Imports	1,249	987	1,610
Unaccounted/Inventory	<u>(608)</u>	<u>(397)</u>	<u>(490)</u>
Total Gas Supply§§	20,084	16,885	18,400

*Data and forecast from DOE Energy Information Administration.

§Includes LPG, jet fuel, kerosine, lubes, and other products.

¶Includes the Strategic Petroleum Reserve.

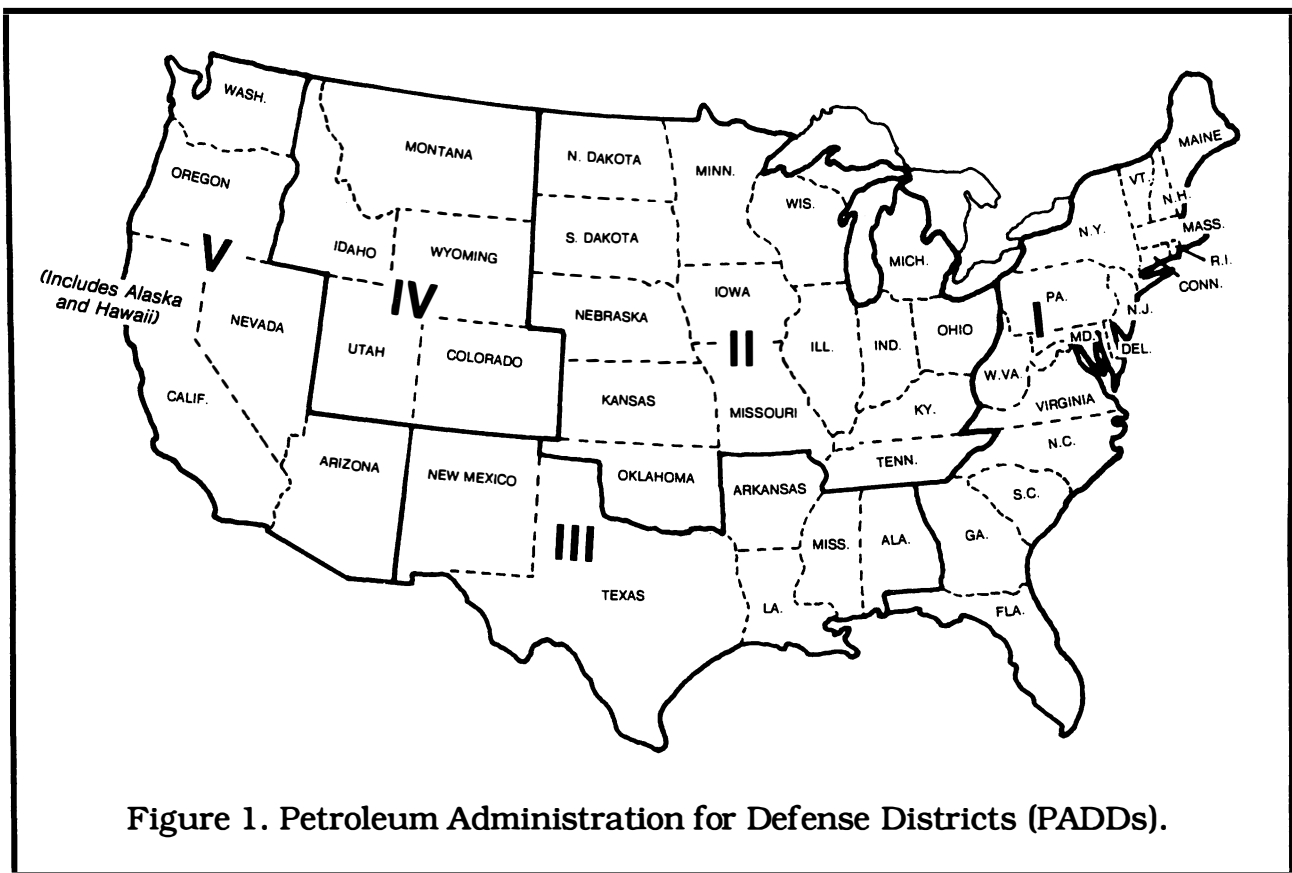
**LPG production, inventory flux, process gain, and other, less exports.

§§Totals may not equal the sum of components due to independent rounding.

peak-year 1979 requirements. Future demands were examined in total and by Petroleum Administration for Defense District (PADD) to identify the areas of principal change such as an increase in foreign crude oil to PADD II (the Midwest) and increased tanker deliveries in the U.S. Gulf.

In this volume, many energy statistics are compiled on a PADD basis. The five PADDs, shown in Figure 1, are consistent with the following broad geographic regions:

- PADD I - East Coast
- PADD II - Midwest
- PADD III - U.S. Gulf Coast
- PADD IV - Rocky Mountain
- PADD V - West Coast.



Gas supply and demand data are also presented in Table 1. Gas demand in the Lower-48 States is projected by the Energy Information Administration (EIA) to increase to 18.4 trillion cubic feet (TCF) per year by 1992, an increase of 1.5 TCF from 1987. This projected rate for 1992 is still about 1.7 TCF below the actual demand in 1979. Overall, this indicates surplus capacity in most of the transportation system. In addition, increased transmission facilities to serve the Northeast and California have been proposed and are awaiting regulatory approval. Additions to current capacity have also been proposed to serve

the Florida markets. If these proposals for capacity additions are approved, there will clearly be adequate natural gas transmission capacity to fully cover expected demand through 1992.

This study examined many aspects of the supply system. They included the gathering of crude oil and its distribution to refineries by pipeline, barge, and ocean tanker and the distribution of product from refineries to consumers by pipeline, barge, tank truck, and rail tank car. Movement of product from foreign sources through the distribution system was also reviewed.

Finally, the changing supply needs of 1992 were compared with anticipated supply and transportation capacity. The supply system appears to have ample capacity and flexibility to handle projected growth in demand through 1992.

THE SUPPLY SYSTEM UNDER STRESS

Satisfied that the system could handle distribution expeditiously under normal growth conditions, the NPC considered the possibility of a variety of sudden and severe crises. In other words, the Council sought to examine the capability of the U.S. distribution system to cope with unusual and unexpected stress.

It is important to mention that even under typical conditions, the system responds to a constant stream of minor stress such as refining down-time, missed pipeline deliveries, unexpected changes in weather, swings in sales, and the like. Occasionally, the system is faced with more serious stress conditions. A degree of stress is normal in the industry, but few stress situations result in serious supply problems. In fact, the consumer rarely feels the impact. The system can respond like a huge shock absorber to changes in demand or supply, because of a built-in level of inventory in storage, considerable product in transit, and of course the ability to move to alternative sources of supply. These features work to give the system its remarkable resilience and flexibility.

The purpose, then, became to test the supply system under conditions of severe or abnormal stress. To do so, six stress scenarios were designed to rigorously test the system's capacity to adapt to sudden and demanding changes in supply requirements. These were:

1. Oil Import Disruption (initiating an SPR drawdown)
2. Colder-Than-Normal Weather
3. Canadian Gas Import Disruption
4. Product Pipeline Disruption (PADD III to PADD II)
5. TAPS Disruption
6. Canadian Crude Oil Import Disruption.

For each of these scenarios, a critical evaluation was made of the system's ability to cope. This included carefully developed

alternative ways to provide the crude oil, product, or natural gas to overcome the crisis situation. Each scenario is briefly described below, along with suggestions as to how the industry could effectively handle the situation.

Scenario 1: Oil Import Disruption

This scenario tests the system's ability to handle a 90-day disruption in foreign crude oil and product imports, totaling 3 MMB/D in 1987 and 4.5 MMB/D in 1992, as outlined in Table 2.

The capacity of the Strategic Petroleum Reserve and the enormous flexibility of the inventory and supply system are adequate to overcome even such an extensive loss of crude oil. The product loss could be made up from both domestic and foreign refineries.

As the scenario is designed, the crude oil loss would vary by region. The most serious supply problem would occur on the East Coast (PADD I). However, crude oil and product can be shifted to meet these needs. Free-market trading is vital to the efficient distribution of SPR oil.

TABLE 2
STRESS SCENARIO 1
ASSUMED IMPORT REDUCTIONS
(Thousands of Barrels per Day)

1987			
	<u>Crude Oil</u>	<u>Product</u>	<u>Total</u>
PADD I	510	420	930
PADD II	270	--	270
PADD III	1,450	210	1,660
PADD V	<u>140</u>	<u>--</u>	<u>140</u>
Total	2,370	630	3,000
1992			
	<u>Crude Oil</u>	<u>Product</u>	<u>Total</u>
PADD I	765	630	1,395
PADD II	405	--	405
PADD III	2,175	315	2,490
PADD V	<u>210</u>	<u>--</u>	<u>210</u>
Total	3,555	945	4,500

In brief, the combination of SPR inventory back-up and the ability of the system to shift product from other parts of the system permit coping with even such large crude oil losses.

Scenario 2: Colder-Than-Normal Weather

This scenario examines how the supply system might cope with an unusually severe winter with temperatures averaging either 10 percent colder than normal for 90 days or 20 percent colder than normal for 30 days throughout the nation. While we have experienced one or the other of these conditions on average once in every five years, these conditions have not been significantly exceeded in the last 50 years.

Both of these conditions could be handled by a combination of inventory drawdowns and a variety of resupply alternatives. This solution would hold both today and for the demand projected for 1992. The point of heaviest stress in this scenario is the deliverability of natural gas to the East Coast, with the area of greatest concern being New England. In that area, some dual-fuel boilers would shift from gas to oil. Construction projects have been proposed, however, to eliminate natural gas pipeline capacity bottlenecks.

In short, the current supply system with the improvements now in progress is fully capable of handling the severest weather conditions we have experienced in over 50 years.

Scenario 3: Canadian Gas Import Disruption

This scenario analyzes the effects of a 50 percent loss in gas imports for the month of January at each of the five entry points between Canada and the United States. The assumed reductions for purposes of this scenario are about 2.3 billion cubic feet per day, as detailed in Table 3.

TABLE 3	
STRESS SCENARIO 3	
<u>DISRUPTION IN CANADIAN GAS IMPORTS</u>	
(Millions of Cubic Feet per Day)	
	<u>Assumed Gas Reduction</u>
PADD I (New England)	25
PADD I (Mid-Atlantic)	100
PADD II	410
PADD IV	555
PADD V (West Coast)	<u>1,235</u>
Total	2,325

This gas loss would be met by calling upon the built-in cushion and flexibility in the system. First, the system inventory would be tapped to meet a large percentage of the shortfall. Second, some fuel switching would take place in the East Coast industrial and electric utility sectors, primarily by drawing on available inventories of residual fuel oil.

In brief, the system could weather the loss of 50 percent of the gas normally imported from Canada for 30 days without significant difficulty. However, the Canadian natural gas shut-off scenario may pose a temporary problem for the West Coast if sufficient natural gas is not in storage at the time of the shut-off. This scenario, therefore, emphasizes the important role of seasonal gas storage in meeting abnormal demands.

Scenario 4: Product Pipeline Disruption (PADD III to PADD II)

This scenario tests supply system capability to respond to a major disruption in a products pipeline flow. For the purposes of this study, the NPC examined the consequences of Explorer pipeline being shut down for 30 days. This pipeline delivers about 360 thousand barrels per day (MB/D) to the Midwest (PADD II) from the U.S. Gulf Coast area (PADD III). This is an important product supply for a high-consumption area. This scenario represents an unlikely stress condition, because product pipelines are repaired quickly; normally only a few days of down time would be expected for a pipeline problem.

Available inventory is usually adequate to cover this assumed product loss. The assumed loss of pipeline deliveries for 30 days would amount to about 10.8 million barrels: roughly equivalent to three day's supply. This is less than the amount of inventory typically available above minimum operating inventory levels in this area, as shown in Table 4. In addition to drawing inventories, a number of alternative means exist to

TABLE 4

PADD II
AVAILABLE SYSTEM INVENTORY -- ABOVE MINIMUM*
(Days Supply)

	<u>Gasoline</u>	<u>Distillate</u>	<u>Jet Fuel</u>
Primary Inventory	4	1	8
Secondary (jobbers, etc.)	4	3	-
Tertiary (consumers)	<u>6</u>	<u>21</u>	<u>6</u>
	14	25	14

*Based on March 31, 1988 data and methodology outlined in Volume IV of this report, Petroleum Inventories and Storage.

increase product supply, including increased refining runs, use of spare capacity in other pipelines, and reduced shipments of product out of the area to regions that can receive product from other sources.

In summary, the loss of a single pipeline into the Midwest for a 30-day period could be handled by a combination of normal industry operating practices.

Scenario 5: TAPS Disruption

This scenario examines the shutdown of deliveries from the Trans-Alaska Pipeline System for 30 days. TAPS is the largest throughput crude oil pipeline in the United States, carrying an average of about 2 MMB/D for transshipment to the West Coast, Gulf Coast, the Virgin Islands, and Hawaii. This constitutes about 15 percent of the total U.S. crude oil demand.

The loss of 2 million barrels of production is a major disruption even in the world market; the loss of 2 million barrels of Alaskan crude oil is particularly difficult because most of the crude oil is consumed on the West Coast, remote from other major crude oil logistics systems. Given current levels of worldwide inventories and surplus foreign production capacity, acquisition of replacement supply for the West Coast should not be a major obstacle; the problem is to maintain continuity of supply until replacement crude oil supply can be delivered.

Replacement of the East-of-Rockies supply poses no major problem, but the situation on the West Coast would be more difficult. The West Coast crude oil loss could be managed by a combination of measures, including: drawdown of inventories, diversion of ships carrying Alaskan crude oil from their intended destinations, and increasing imports of crude oil and product.

Thus, while the disruption of TAPS would result in higher cost to the marketplace, essential supply needs would be met, assuming normal world crude oil supply availability, especially in a current disruption. However, the loss of TAPS supply for 30 days in 1992 could pose a substantially more serious problem, which would be felt by West Coast consumers for several weeks. The West Coast re-supply problem will become more difficult in later years as projected Alaskan production drops and West Coast consumption increases, leaving significantly less oil in transit to provide continuity in the early days of the cut-off.

Scenario 6: Canadian Crude Oil Import Disruption

The final stress scenario tests options available in case of a 30-day disruption of Canadian crude oil imports delivered via Inter-Provincial pipeline. This would result in a 500 MB/D crude oil loss in the Upper Midwest.

Supply to cover a 30-day Canadian crude oil disruption is normally available from primary crude oil inventories in the

Midwest and Gulf Coast. Pipeline capacity to move the crude oil to the affected areas is also available. Inventories would be replenished with increased non-Canadian imports later in the stress response cycle. The system also retains the flexibility to supply significant volumes of finished product into the affected areas. By 1992, projected growth in refinery crude oil demand will make replacement of the Canadian volume in kind more difficult. Incremental product supply and product inventory draw would be required to bridge a 30-day loss of Canadian crude oil.

For most of the Midwest, the lost Canadian crude oil could be replaced quickly except for the Twin Cities area.

Summary

Designing and examining these six scenarios has served to highlight some important factors about our supply system:

- The system is very resilient and flexible, permitting it to adjust to and resolve a wide range of stress situations.
- This flexibility and adaptability depend heavily on built-in inventories that occur at key points in the system, and on the system's great capacity to obtain crude oil, product, or natural gas from alternative supply sources.
- The interconnectability of the individual parts of the system permits shifting and diverting product from many sources to virtually any point of ultimate consumption. In this sense, the U.S. and worldwide petroleum distribution networks are the most widespread of any logistic systems in the world.

It is important to recognize that these stress scenarios examined the ability of the system to move crude oil, product, and gas in abnormal conditions. In all the scenarios, supply was expected to be available in the system. Obviously, the system could not resolve situations in which there was not adequate supply available to the system. In this respect, the Strategic Petroleum Reserve provides an important source of potential supply, if required.

Finally, the study has made it clear that economics and the free market drive this system. It is a simple but profound concept: as supply shortages develop, prices rise, encouraging a shift to rebalance the disposition of crude oil, product, or natural gas. When artificial constraints are placed on the system, the natural balancing, self-correcting process does not work.

Since the end of World War II, no serious petroleum shortages have occurred at the consumer level except gasoline lines and natural gas curtailments in the era of price and allocation

controls. In recent years, however, there have been situations where the market felt particularly heavy pressure because of abnormal conditions. These included:

- Motor gasoline supply tightness in the summer of 1988
- The fuel-switching episode of 1986
- The Southwest freeze-up of 1983.

While these events had their economic cost and produced a high level of discomfort for oil and gas companies, they did not prove in any way disruptive -- convincing testimony to the flexibility and adaptability of our supply system.

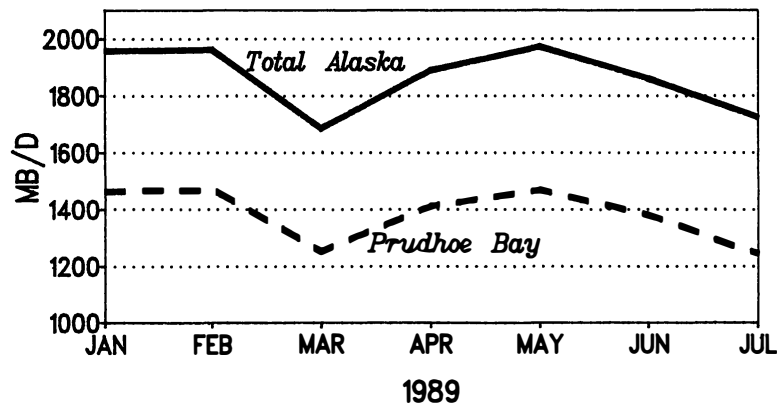
VALIDATION OF
NPC *SYSTEM DYNAMICS* VOLUME
BY RECENT EVENTS

THE SYSTEM UNDER STRESS

MARCH 1989 TANKER ACCIDENT

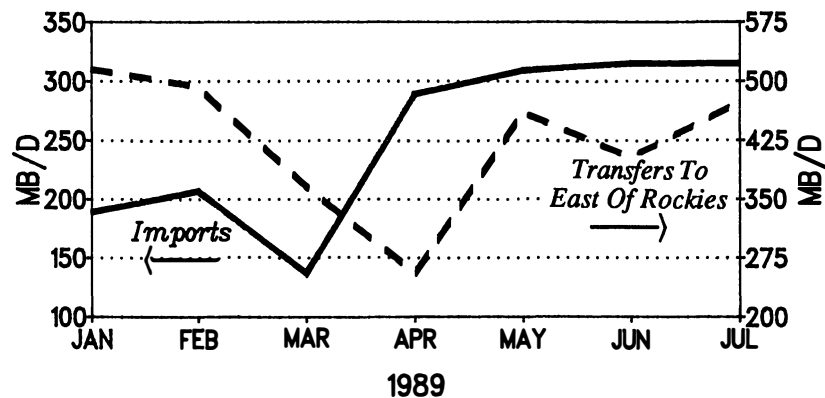
PAD DISTRICT 5

Alaskan Crude Oil Production



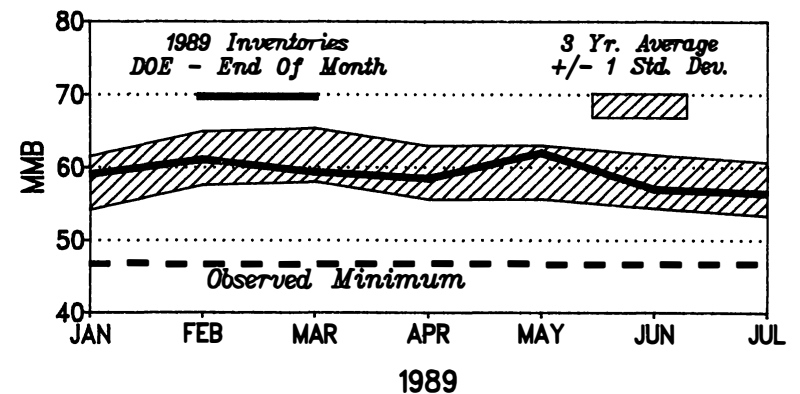
SOURCE: EIA Petroleum Supply Monthly, July 1989.

Crude Imports & Inter-PADD Transfers



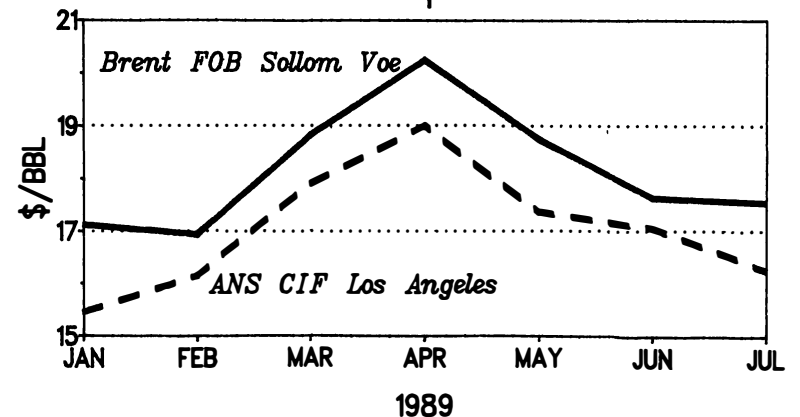
SOURCE: EIA Petroleum Supply Monthly, July 1989.

Crude Oil Inventories Excluding ANS In Transit



SOURCE: EIA Petroleum Supply Monthly, July 1989.

Crude Oil Spot Price



SOURCE: Platts Oilgram Price Reports.

**THE SYSTEM UNDER STRESS
MARCH 1989 TANKER ACCIDENT
CRUDE OIL SUPPLY RESPONSE**

On March 24, 1989, a tanker ran aground in Prince William Sound. For almost two weeks shipments of oil from Alaska were disrupted, causing production in the North Slope to be shut in.

While national attention was focused on the tragic events in Prince William Sound, petroleum suppliers, particularly those on the West Coast, immediately began rebalancing their systems with crude oil and refined products from inventories, as well as shipments from other parts of the nation and overseas.

These charts illustrate how the crude oil system was brought back into balance on the West Coast:

- Production of Alaskan crude oil declined an average of 250 thousand barrels per day (MB/D) in March 1989.
- The immediate psychological impact of the lost supply as well as the uncertainty of how long the disruption would last caused the spot price of Alaskan North Slope (ANS) crude oil to rise precipitously.
- The higher prices attracted foreign cargoes of crude oil; the April import level was twice the March level.
- At the same time, ANS cargoes in transit to the Gulf Coast were diverted back to West Coast refineries.
- These moves were supplemented by a slight decline in on-land crude oil stocks during April.
- The adjustments overcompensated somewhat, and on-land stocks increased in May.
- By July crude oil prices had returned to their pre-shock level.

Although these charts focus on the west of the Rockies system, it should be noted that the impact of this disruption was felt worldwide. Prices increased in all parts of the world, as the loss of Alaskan oil represented a net loss in total world crude oil availability. Cargoes were redirected and inventories pulled in the U.S. east of the Rockies system, and other parts of the world as well.

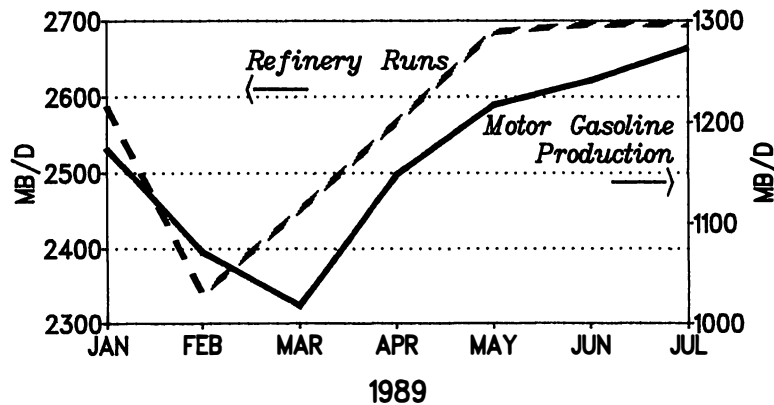
CONCLUSION—The market response to the Alaskan supply disruption demonstrated the resilience of the system. Price signals were quickly acted upon and operations returned to normal with little or no inconvenience to the final consumer.

THE SYSTEM UNDER STRESS

MARCH 1989 TANKER ACCIDENT

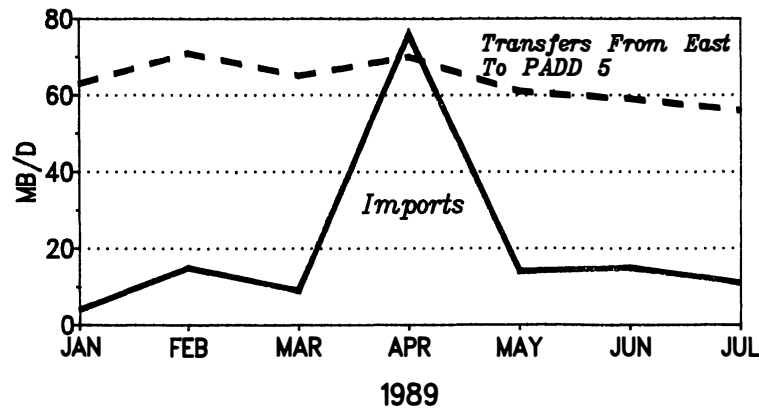
PAD DISTRICT 5

REFINERY RUNS & MOTOR GASOLINE PRODUCTION



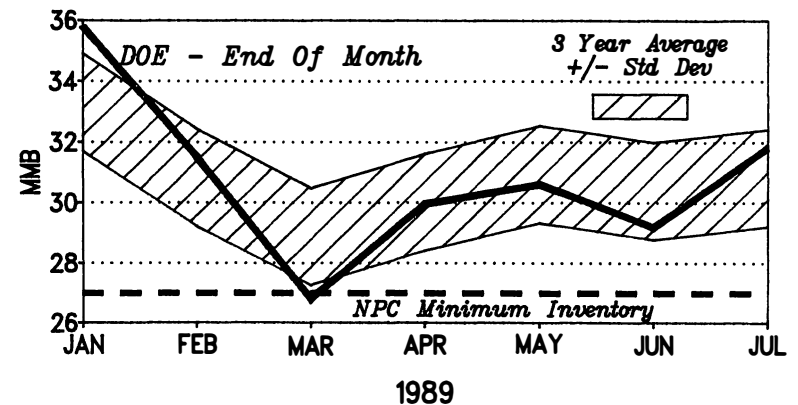
SOURCE: EIA Petroleum Supply Monthly, July 1989.

MOTOR GASOLINE IMPORTS & INTERPADD TRANSFERS



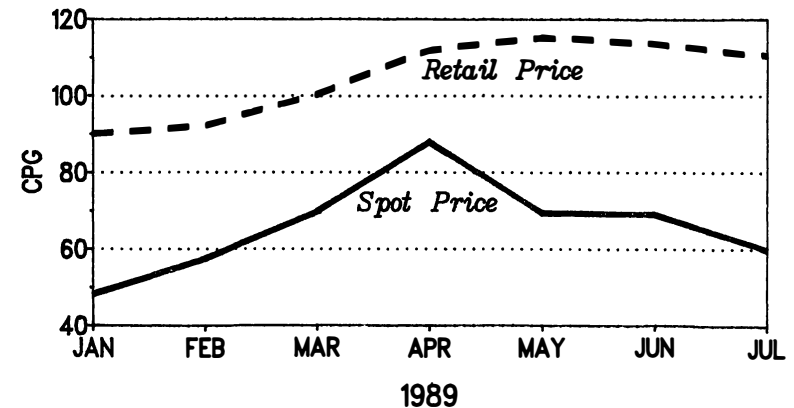
SOURCE: EIA Petroleum Supply Monthly, July 1989.

MOTOR GASOLINE INVENTORIES



SOURCE: EIA Petroleum Supply Monthly, July 1989.

LOS ANGELES REGULAR UNLEADED MOTOR GASOLINE PRICES



SOURCE: Platts Oilgram Price Reports.

**THE SYSTEM UNDER STRESS
MARCH 1989 TANKER ACCIDENT
MOTOR GASOLINE SUPPLY RESPONSE**

When the disruption occurred, the product supply situation was already tight on the West Coast. There were several factors that contributed to this situation:

- Several refineries were undergoing planned maintenance and unplanned shutdowns.
- It was the beginning of the peak driving season (the accident occurred on Good Friday).
- Refiners and terminal owners had drawn down inventories in preparation for the seasonal reduction in Reid Vapor Pressure (RVP) specifications for motor gasoline.

The charts show the supply elements for motor gasoline before and after the disruption, and demonstrate the rapid response to the price change that occurred in March/April.

- Refinery downtime had caused motor gasoline inventories to decline near minimum operating levels prior to the accident.
- The price of motor gasoline had already begun to increase prior to the disruption; its rise was exaggerated by the psychological impact of the crude oil supply loss.
- The system response to the price rise was an increase in refinery runs and motor gasoline production, a surge in imports, and an increase in transfers from east of the Rockies.
- By the end of May, motor gasoline inventories had returned to a more comfortable level and prices had dropped by 20 cents per gallon (cpg) and were poised for further declines.
- These charts depict monthly average prices; the price changes were actually much more dramatic, increasing by 34 cpg in the four days following the accident, declining by 20 cpg within twelve days (as the uncertainty of crude deliveries eased), then dropping an additional 13 cpg over the next month.

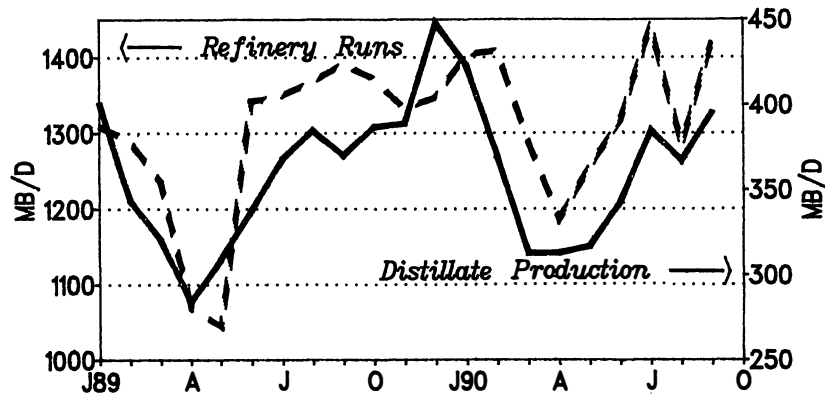
At the consumer level the price rise was not so dramatic, and service stations were able to continue to supply customers without disruption. However, there were cases of scattered runouts at the terminal level as some jobbers panicked and began raiding terminals. Rationing was put in place by terminal suppliers and the system quickly returned to business as usual.

CONCLUSIONS—Motor gasoline represents the market segment that is most visible to the American consumer. While there were price increases at the pump, they were not as dramatic as the rise in spot prices. The consumer did not suffer any inconvenience as a result of the disruption, as supply and demand quickly resumed to pre-crisis conditions.

THE SYSTEM UNDER STRESS

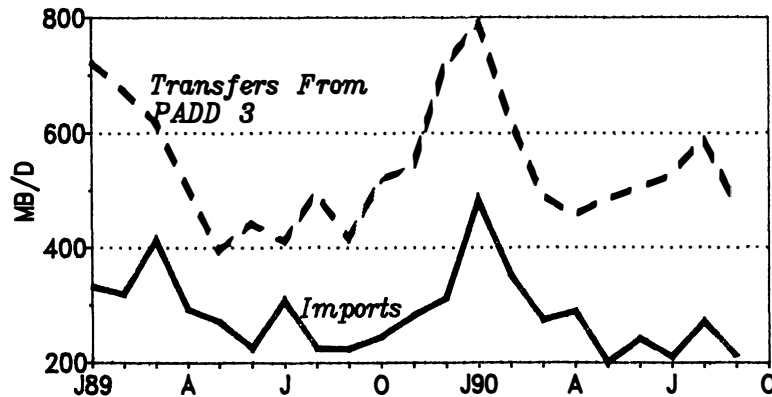
WINTER 1989
PAD DISTRICT 1

REFINERY RUNS & DISTILLATE PRODUCTION



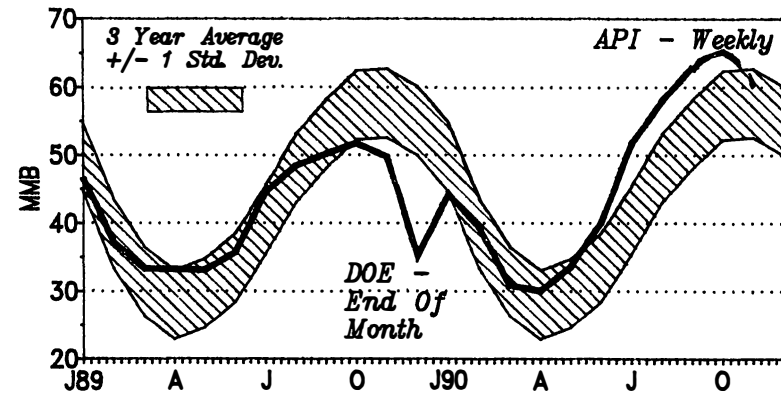
SOURCE: EIA Petroleum Supply Monthly, October 1989.

DISTILLATE IMPORTS & INTERPADD TRANSFERS



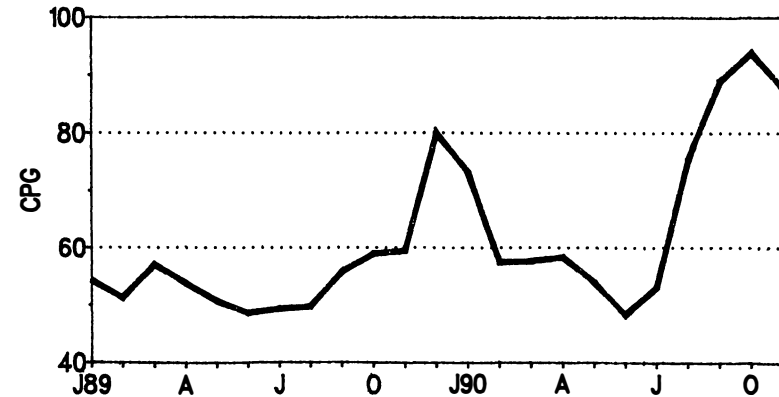
SOURCE: EIA Petroleum Supply Monthly, October 1989.

DISTILLATE INVENTORIES



SOURCE: EIA Petroleum Supply Monthly, October 1989.

NEW YORK HARBOR SPOT DISTILLATE PRICE



SOURCE: Platts Oilgram Price Reports.

THE SYSTEM UNDER STRESS
WINTER 1989
PADD 1

In the winter freeze of December 1989, damage occurred to a number of U.S. Gulf Coast refineries and a major disruption in refiners' petroleum product availability was perceived to be imminent.

With this shutdown, the distillate demand increased immediately as buyers, especially in PADD 1, were willing to pay more for supply continuity and avoid future price increases.

The wholesale price of No. 2 heating oil shot up. Higher prices created production incentives for refiners unaffected by the freeze, and refineries resuming operations after the freeze caused more production to eventually be brought to the marketplace.

This increased refinery production, coupled with relatively warm weather for the remainder of the winter, generated a market perception that a surplus was developing and prices fell sharply.

CONCLUSION—The petroleum distribution system responded to temporary imbalances in supply and demand through higher prices, which were quickly followed by increased supplies and declining prices.

INDEX

INDEX

A

Alaska, 15, 43, 57, 65
Algeria, 39

B

Butane, 34

C

Canada, 39
Coal, 56, 58, 65
Consumer education, 7
Crude oil. See also various listings under Petroleum
 futures market transactions, 23
 inventories, 17
 in NPC test cases, 65-68, 70, 73-75
 quality, 5, 7, 29, 45
 supply disruption, 4, 7, 34, 40, 43
 world market for, 13
Crude oil prices
 effect of Iraqi invasion on, 25
 transmission of information, 21
Crude oil production
 impact of loss in, 31
 status of, 5, 6, 34
 U.S., 15, 56-57

D

Demand. See also Supply/demand outlook
 economics of, 19
 forecasts, 52-56, 59, 60
 impact of Iraqi invasion on, 25
 for propane, 39
Department of Transportation, 41
Distillate fuel oil
 demand and price models, 53-54
 in NPC test cases, 68, 70, 71, 75
 for Operation Desert Shield, 27
Distribution system
 effect of stress situation on, 2
 inventories, 17
 for propane, 37, 39
 for SPR supplies, 6, 40, 43, 45
 U.S., 4, 15
DRI/McGraw-Hill Quarterly Macroeconomic Model, 50-51, 70, 75

E

Economic test case (NPC), 75-76
EIA. See Energy Information Administration
EIA *Short-Term Energy Outlook*, 1-4, 8-10
EIA *Short-Term Energy Outlook* process and models review
 data bases and data flow, 49-50
 integration and reconciliation, 60-65
 international supply and demand, 58-60
 macroeconomic forecast, 50-51
 model capabilities—NPC economic test case, 75-76
 model capabilities—NPC price test case, 65-75
 observations, 76
 U.S. energy demand and price models, 52-56
 U.S. energy supply model, 56-58
Electricity, 55-58, 70, 74
Energy demand forecasts, 52-56
Energy Information Administration (EIA)
 International and Contingency Information Division (ICID), 58-59
 Office of Coal, Nuclear, Electric and Alternate Fuels (CNEAF), 71-73
 Short-Term Energy Outlook. See EIA *Short-Term Energy Outlook* process and models review
 supply/demand projections, 2, 8-10
Energy policies. See Government energy policies
Environmental Protection Agency (EPA), RVP standards, 41
Ethane, 54, 55
Exports
 effect of Iraqi invasion on, 25, 26
 U.S. propane, 39
 U.S. refined product, 5

F

Forecasts, macroeconomic, 50
Fuel oil. See also Distillate fuel oil; Residual fuel oil
 demand and price models, 53-54
 for power generation, 10

Fuel switching, 29
Futures markets
 function of, 7-8
 price information transmitted
 by, 21
 price transparency and reduced risk
 mechanism provided by, 23

G

Gasoline
 demand and price models, 52-53
 futures market transactions in, 23
 in NPC test cases, 66, 68, 75
 Reid Vapor Pressure (RVP) regulations
 and, 7, 34, 41
Government energy policies
 effects of intervention, 4, 7, 19, 35
 options, 3
 regarding propane supply
 interruption, 39
 system distribution recommen-
 dations, 6-8, 40-41, 43

H

Heating oil, 23
Hedging, 23
Hoarding, 6

I

ICID (International and Contingency
 Information Division), 58-59
IEA. See International Energy Agency
Imports
 crude oil, 13, 15
 petroleum products, 13, 15
 propane, 39
 U.S. product, 5
International and Contingency
 Information Division (ICID),
 58-59
International Energy Agency (IEA),
 release of strategic stocks, 3,
 6, 34
International Maritime Organiza-
 tion, 40
International Petroleum Exchange, 21
Inventories
 impact of futures markets prices
 on, 23
 profile of crude oil and product, 17
Iraq
 invasion of Kuwait, 25
 loss of crude oil production from, 5

J

Japan, 27
Jaw-boning, 7, 18
Jet fuel
 demand and price models, 53
 Desert Shield needs, 27, 33
 in NPC test cases, 68, 75
Jones Act tankers
 adequacy of fleet, 29
 availability of, 6
 and pipeline shutdowns, 35
Jones Act waivers
 as response to propane supply
 interruptions, 39
 in system disruption, 3, 6, 34,
 40, 43, 45

K

Kerosene, 55
Kuwait
 Iraqi invasion of, 25
 loss of crude oil production and
 refined products from, 25
 refining capacity of, 5, 27

L

LIHEAP (Low Income Home Energy
 Assistance Program) funds, 35,
 39, 41
Liquified petroleum gases (LPG), 54
Logistical system, U.S., 20, 34
Logistics, assessment of capabilities, 3

M

Macroeconomic forecasts, 50-51
Mexico
 as source for propane, 39
 SPR oil supplied by, 45
Minimum operating inventories
 (MOI), 17

N

National Petroleum Council (NPC)
 economic test case, 75-76
 findings and conclusions of, 3-4
 price test case, 65-75
Natural gas
 availability, 54
 futures market transactions in, 23
 prices, 66
 substitution of, 10, 39, 76
 supply and demand forecasts, 56, 58

New York Mercantile Exchange
(NYMEX), 23

O

Office of Oil and Gas (O&G), 71-73
Oil Market Simulation Model
(OMS), 58
Oil spill liability provisions
pre-emption during system
disruption, 40
state, 8, 29
OPEC production, 59
Operation Desert Shield, 27, 33

P

Petrochemical feedstocks, 54, 55
Petroleum industry, 7
Petroleum markets
effect of use of SPR on, 6
profile of U.S., 15
profile of world, 13
transmission of price information
in, 21
worldwide supply/demand outlook,
4, 59
*Petroleum Prices and Profits in the
90 Days Following the Invasion
of Kuwait* (EIA), 2, 4, C-1—C-3
Petroleum products
demand and price models, 52, 55
effect of Iraq invasion on price
of, 25
government responses to system
disruptions, 41
inventories of, 17
NPC price test case, 65-75
relaxation of quality regulations,
7, 41
transmission of price information
for, 21
U.S. distribution system for, 4, 15
U.S. market for, 15
world market for, 13
Pipelines
response to changing needs of, 29
shortages from unanticipated U.S.
shutdown, 6, 35
Price
as communications network, 13
effect of government intervention
on, 4, 7, 8
effect of Iraqi invasion on, 25
effect of production loss on, 31
impact of supply/demand on, 19, 25
role of futures markets in, 23

transmission of information regard-
ing, 21

Price controls. See also Government
energy policies
distortion of supply and demand
by, 19

long-term effects of, 7

Price test case (NPC), 65-75

Primary distribution system inven-
tories, 17

Production

crude oil, 5, 6, 15, 34, 56-57

effect of loss of supply/demand
outlook, 31

increases resulting from Iraqi
invasion, 25

OPEC, 59

Propane

distribution system for, 37

futures market transactions in, 23

overview of, 37

supply/demand information for, 39

Publications, trade, 21, 49

R

Refineries

categories of, 5

unanticipated shutdowns in, 35

Refining capacities

assessment of, 3, 33

conversion balance of, 5

disruptions to Kuwaiti, 27

disruptions to world, 5-6, 27

U.S., 5, 34

Reid Vapor Pressure (RVP) regulations, 7,
34, 41

Residual fuel oil

demand and price models, 54

futures market transactions in, 23

in NPC test cases, 68, 70-73, 75

production capacity for, 29

Risk reduction, 23

S

Saudi Arabia

refinery output in, 27

supply of jet fuel for Desert Shield
Operations by, 33

Secondary inventories, 17

Short-Term Energy Outlook (EIA),

1-4, 8-10. See also EIA *Short-Term
Energy Outlook* process and models
review

*Short-Term Integrated Forecasting
System, 1990 Model Documentation
Report* (DOE), 49

- Short-Term Integrated Forecasting System (STIFS), 49, 58-60, 63, 68, 69, 71-72, 74-75
- Short-Term Integrated Model (STIM), 63-65
- Singapore Mercantile Exchange, 21
- Spot prices, 21
- SPR. See Strategic petroleum reserve (SPR) oil
- State energy policies. See also
 Government energy policies
 federal vs., 3, 8
 on oil spill liability provisions, 8, 29
 as response to system disruptions, 41
- STIFS. See Short-Term Integrated Forecasting System
- STIM (Short-Term Integrated Model), 63-65
- Strategic petroleum reserve (SPR) oil
 delivery requirements of, 43
 Jones Act waivers for release of, 3
 profile of, 45
 release of, 3, 6, 34, 40
- Sulfur content
 differences in, 5, 7
 relaxation in specifications, 7, 29, 41
- Supply
 assessment of current situation, 3
 disruptions in. See Crude oil; Petroleum products
 EIA analysis following Iraqi invasion, 2
 impact of Iraqi invasion on, 25
 outlook of world, 59, 60
 of propane, 39
 U.S. energy model, 56-58
- Supply/demand forecasts. See also EIA
Short-Term Energy Outlook process
 and models review
 EIA, 2, 8-10
 macroeconomic assumptions needed for, 50-51
- Supply/demand outlook
 crude oil and product inventories
 effect on, 17
 current system capability effect
 on, 27, 29
 domestic issues impacting, 34-35, 37, 39
 effect of price on, 19, 21
 findings and conclusions of, 3-4
- futures market and, 23
 government responses to system
 disruptions and, 40-41, 43
 Iraqi invasion and U.N. embargo effect
 on, 25
 issues in short-term, 4-8
 production loss affect on, 31
 SPR and, 45
 U.S. petroleum market effect on, 15
 world petroleum market effect on, 13
 world refining capacity effect on, 33
- System Dynamics volume of *Petroleum Storage & Transportation* (NPC), 2, 4
- Executive Summary, D-1—D-14
 validation by recent events,
 D-16—D-21
- T**
- Tankers. See Jones Act tankers; Jones Act waivers
- Tertiary inventories, 17
- Trade publications, 21, 49
- U**
- Unified Demand and Price Analysis Subsystem (UDAPAS), 75
- United States
 average imports and exports, 5
 energy demand and price models, 52-56
 energy supply model, 56-58
 forecast of economy, 50-51
 petroleum markets in, 15
 refining capacity of, 27
 refining system of, 5
- U.S. Maritime Administration, 43
- W**
- Waiver process. See also Jones Act
 waivers
 for distribution of SPR oil, 3, 6
- Weather
 effect on propane supply/
 demand, 39
 system disruptions/shortages
 due to, 6, 35
 as variable in energy demand
 forecasts, 55
- Wet-barrel transactions, 23



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